



AIDS TO NAVIGATION MANUAL - STRUCTURES



COMDTINST M16500.25
AUGUST 2003

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CHAPTER 1. INTRODUCTION

- A. General. Aids to navigation (ATON) structures support visual and audible signal equipment in a fixed location and at a design elevation that establishes the geographical range of the aid. Structures are built in a variety of configurations according to the unique geological and environmental conditions of a given location, as well as the specific nature of the signal required. They can range from simple and inexpensive daybeacons to complex and costly offshore lights. Design work, particularly for complex structures, is normally performed by the Civil Engineering Units (CEUs) or via CEU-administered contracts. Construction is carried out via CEU-administered commercial contracts, or in the case of many minor structures, by Coast Guard construction tenders (WLICs). Design, construction, and maintenance of ATON structures are functions of the Shore Facilities Program, and are funded via the AC&I Waterways program or the AFC-43 program, depending on the nature of the work involved. Guidance for these funding methods is provided in the Shore Facilities Manual, COMDTINST M1100.13 (series) and the Financial Resource Management Manual, COMDTINST M7100.3 (series).
- B. Classification of ATON Structures. There are currently over 22,000 ATON structures in use Coast Guard-wide. For purposes of definition, and to facilitate planning and discussion, they are commonly grouped into the three categories listed below.
1. Minor ATON Structures. Minor ATON structures are relatively simple in design and construction, and are usually made of wood or concrete piles, steel piles, or other steel structural shapes. They can be either lighted or unlighted. The same type of structure or a similar type is built repetitively and only minimal engineering analysis of individual site locations is required. Examples of minor ATON structure types are included in the data sheets at the end of this manual.
 2. Major ATON Structures. Major ATON structures are complex in design and construction and usually require significant engineering effort, including geotechnical and hydrographic site analysis. Although there may be similarities in the design of the various types of major ATON structures, each structure is normally one-of-a kind and specifically tailored to the unique environmental conditions and operational requirements of a given location. Ranges and large offshore lights would be typical examples of major ATON structures.
 3. Lighthouses. A lighthouse structure is an enclosed edifice which houses, protects, displays, or supports visual, audible, or radio aids to navigation. These structures are usually made of granite, brick, cast iron plate, monolithic stone, concrete, or steel. They are often located in an offshore, wave-swept, exposed environment, or on a coastline as a landfall object. In the past, these were manned structures, but almost all have at this point been fully automated. This manual will not address lighthouses. Guidance on lighthouses can be found in several of the documents listed in paragraph 1.D.1.
- C. Roles and Responsibilities. There are several Coast Guard activities involved in various aspects of ATON structure design, construction, and maintenance. A brief description of

their roles and responsibilities is given below. In addition, numerous stakeholders and customers external to the Coast Guard have an input in the process, such as private and commercial mariners, pilot associations, and government entities at various levels (Federal, state, and local).

1. Commandant (G-OPN). Commandant (G-OPN) is the short range aids to navigation program manager, and establishes administrative and operational policy for this Coast Guard mission area.
 2. Commandant (G-SEC). Commandant (G-SEC) is the engineering support manager for the short range aids to navigation program. This office establishes engineering policy and procedures relevant to ATON structures, equipment, and systems; manages funding for ATON facility construction and maintenance; and oversees the execution of the AC&I Waterways marine construction program.
 3. Districts (oan). Districts (oan) identify the operational requirements for a given ATON station and any resulting need for an appropriate structure from which to display its signal. District tenders and ANTs operate and maintain the signal equipment and systems at the structures. District ATON units (e.g., WLICs) also build and replace minor ATON structures. ATON units that observe safety and/or structural deficiencies while servicing ATON equipment and systems provide this information to the CEUs to initiate corrective action.
 4. Civil Engineering Units (CEUs). CEUs perform engineering design of ATON structures and administer contracts for design and construction services. They perform engineering inspections (or contract for these services), and oversee maintenance and repair activities. They are responsible for establishing climber training requirements and overseeing climber training. They purchase structure outfitting equipment and other supplies for the ATON fleet, including piles for WLIC construction activities.
- D. Reference Documents. The following documents contain information which is relevant to ATON structures, and are referenced when applicable throughout this manual.
1. Coast Guard Directives.
 - a. Tower Manual, COMDTINST M11000.4 (series). This manual defines Coast Guard policy and criteria for the preservation, inspection, and maintenance of towers (other than ATON structures).
 - b. Shore Facilities Manual, COMDTINST M11000.13 (series). This manual establishes the policies and strategies for management of the civil engineering program and the shore facility capital asset related processes that sustain Coast Guard missions. It also provides comprehensive guidance on the execution of AC&I Waterways marine construction projects.

- c. Financial Resource Management Manual, COMDTINST M7100.3 (series). This manual prescribes Coast Guard financial resource management policy.
 - d. Coatings and Color Manual, COMDTINST M10360.3 (series). This manual provides guidance on coatings for vessels, buildings, structures, fixed equipment, and aids to navigation.
 - e. Aids to Navigation Manual - Technical, COMDTINST M16500.3 (series). This manual contains the instructions and policies governing the selection, installation, and maintenance of equipment for the Short Range Aids to Navigation Program.
 - f. Range Design Manual, COMDTINST 16500.4 (series). This manual provides general guidance for the design of two-station ranges as well as specific instructions on the use of a computer program for the detailed design of two-station ranges.
 - g. Lighthouse Maintenance Management Manual, COMDTINST 16500.6 (series). This manual provides information, principles, policies, and requirements for the maintenance of lighthouses.
 - h. Aids to Navigation – Administration, COMDTINST M16500.7 (series). This manual promulgates policy and guidance for the administration of the Short Range Aids to Navigation Program.
 - i. Automation Technical Guidelines, COMDTINST 16500.8 (series). This document presents technical philosophies and guidelines which should be used in selecting and designing equipment and systems for automated aids to navigation at lighthouses and ranges.
 - j. Major Aids to Navigation Preventive Maintenance System Manual, COMDTINST 16500.10 (series). This manual promulgates equipment-specific Preventive Maintenance System (PMS) cards for preventive maintenance of standard lighthouse and range equipment.
 - k. Alternating Current Aids to Navigation Servicing Guide, COMDTINST M16500.17 (series). This manual is a field guide for Coast Guard personnel who service aids to navigation hardware powered by alternating current.
 - l. Short Range Aids to Navigation Servicing Guide, COMDTINST M16500.19 (series). This manual is a field guide for Coast Guard personnel who service aids to navigation hardware powered by direct current.
2. Publications from Other Federal Agencies. Many of the following documents are available on line. Where available, the Internet addresses are provided below.
- a. Design of Pile Foundations (EM 1110-2-2906). This U.S. Army Engineering Manual provides foundation exploration and testing procedures, load test methods, analysis

techniques, allowable criteria, design procedures, and construction considerations for the selection, design, and installation of pile foundations.
(<http://www.usace.army.mil/inet/usace-docs/eng-manuals/em1110-2-2906/toc.htm>)

- b. Pile Construction (FM 5-134). This U.S. Army Field Manual covers pile design, material selection, pile-driving equipment, pile installation, and pile maintenance.
(<http://155.217.58.58/cgi-bin/atdl.dll/fm/5-134/toc.htm>)
 - c. Pile Driving Equipment (TM 5-849-1). This U.S. Army Training Manual covers the selection and use of a variety of pile driving equipment and methods.
(<http://usace.army.mil/publications/armytm/tm5-849-1/toc.htm>)
 - d. Soil Mechanics (DM 7.01), and Foundations and Earth Structures (DM 7.02). These two U.S. Navy Design Manuals cover the application of basic engineering principles of soil mechanics in the design of foundations and earth structures.
(<http://www.lantdiv.navfac.mil>)
 - e. Climbing Safety Equipment (RR-S-001301). This Federal Specification covers the requirements for ladder safety devices.
3. Federal Regulations. The following documents are from the Code of Federal Regulations (29 CFR, Chapter XVII - Occupational Safety and Health Administration). They cover various aspects of worker safety that are relevant to ATON structures, and will be referenced as applicable throughout this manual.
- a. Part 1910 - Occupational Safety and Health Standards. This document contains requirements for ladders, ladder safety devices, and platform railings.
 - b. Part 1915 - Occupational Safety and Health Standards for Shipyard Employment. This document contains requirements for personal fall arrest systems and positioning devices.
 - c. Part 1926 - Safety and Health Regulations for Construction. This document contains requirements for ladders, ladder safety devices, fall protection, and pile driving operations.

CHAPTER 2. DESIGN CONSIDERATIONS

- A. Introduction. This chapter provides general guidance for the design of ATON structures. The information provided herein is not all-inclusive. Specifically, detailed guidance for the engineering design of major ATON structures is beyond the scope of this manual. This is due to the complexity of the work involved, and the need to accommodate specific environmental conditions and operational requirements which are unique to each project. The primary focus will therefore be on minor ATON structures, although much of the guidance will be applicable in varying degrees to all structure types. Previous editions of this manual included a lengthy section on structural design theory. That information has been removed, since it duplicated guidance that is presented in a more current and comprehensive form in standard engineering reference works, such as those listed in paragraph 1.D.2.
- B. Design Overview. Both major and minor ATON structures have basic design characteristics in common. They have a foundation, a platform to hold the signal equipment, and a vertical structural member to elevate the platform above the foundation. The difference between major and minor ATON structures is in the size and complexity of these components. For example, one of the most common minor ATON structure designs in the Coast Guard is the "single pile wood" (SPW). It consists of a preservative-treated wood pile driven into the bottom, with a prefabricated wooden platform mounted on top of the pile to hold the signal equipment. In this case, the pile serves as both the foundation and the vertical structural member for the aid. There are literally thousands of these inexpensive SPWs throughout the Coast Guard. An example of a structure design at the other end of the spectrum would be Ambrose Light in New England. Completed in 1999 at a cost of \$4.4 million, this major ATON structure consists of a 73 ton, 80-foot tower supported by a 177-ton tripod jacket structure in 95 feet of water, anchored by 48-inch diameter steel pipe piles extending 175 feet below the mudline. Between these two extremes are a wide range of structure types, the vast majority of which are minor ATON structures in single-pile or multiple-pile configurations.
- C. Design Responsibilities. ATON structure designs should be based on sound engineering principles and practices, and the engineering professional should take full advantage of the structural design guides, engineering reference works, and computer design programs that are widely available in the public domain. Examples of Federal publications with guidance relevant to ATON structures are provided in paragraph 1.D.2. Standard designs for minor ATON structures are provided in the data sheets at the end of this manual. While there are no "standard" designs for major ATON structures, engineering drawings and specifications for designs that have previously been built would be available for reference from the cognizant CEU. Individuals tasked with the design of ATON structures are strongly encouraged to maintain open lines of communication with their colleagues inside and outside the Coast Guard to share information on best practices, unique design solutions, and sources of engineering design guidance.
1. Major ATON Structures. The CEUs are tasked with the design of major ATON structures. This design work might be carried out by CEU staff, or contracted out by the CEU to an architect/engineering (A/E) firm.

2. Minor ATON Structures. By definition, there is normally little design work required for minor ATON structures. These aids are often built repetitively, based on standard design configurations of the type shown in the data sheets at the end of this manual. This is especially the case for single-pile and multiple-pile structures built by Coast Guard construction tenders (WLICs) in the East Coast and Gulf Coast regions, which account for a sizeable portion of the Coast Guard's ATON structure inventory. Nevertheless, the engineering design of specific minor ATON structures, when required, is a CEU responsibility. An example would be when structures are required in Districts with no WLIC capability, and construction must be done by contract. The CEU would provide the design, establish the contract for the work, and oversee the construction.

D. Design Factors. The following factors should be considered in the design process, regardless of the size or complexity of the structure in question.

1. Payload. This would include the dead load (power system, signal equipment) and live load (servicing personnel) expected to be on the structure at any given time.
2. Weather. Structures shall be designed to resist those wind, wave, and current forces that occur in a design storm for the site location. In general, minor ATON structures should be designed to resist the 10-year storm, and major ATON structures the 50-year storm.
3. Site Location. The design must take into account the depth of water and bottom conditions at the site location. Water depth has a direct effect on wave and current forces, while the bottom type (rock, coral, gravel, sand, clay, or silt) has a significant influence on the stability of the structure and is fundamental to its design. In addition, there may be obstructions on the bottom that could interfere with pile driving and construction: large boulders, underwater cable, submerged wrecks. It may be necessary to perform hydrographic, geotechnical, underwater video, or side scan sonar surveys as part of the design effort if sufficient data is not available about the conditions of the site. An archaeological survey may be required if the site is known to potentially contain historic artifacts. These site surveys would normally be contracted out by the CEU as part of the design process.
4. Ice Conditions. If ice conditions at the site are severe enough to destroy commonly used structures and occur more frequently than the design storm, then a choice would have to be made among one of the following alternatives: (a) use a buoy instead of a structure; (b) consider the structure sacrificial and expect to replace it periodically; (c) specifically design the structure to resist the expected flow and thickness of ice. The alternative selected would depend on the operational requirements of the site (e.g., whether or not a buoy would be an acceptable substitute for a structure) and the economic realities involved (e.g., the relative cost of maintaining and servicing a buoy station, replacing an ice-damaged structure repeatedly, or building an ice-resistant structure). This decision would normally be made on a case-by-case basis by the District (oan) in partnership with Commandant (G-OPN), and in consultation with Commandant (G-SEC) and the cognizant CEU.

5. Operational Requirements. The height of an ATON structure is one of the most important factors in its design. It affects the distance at which the aid may be seen (geographic range), the cost of construction, and the contrast of the aid with the background. Minor ATON structures should have a focal plane height of 15 to 17 feet. Specific aids may be raised higher if objects, such as trees or vegetation, would obscure the aid at this recommended height. The focal height of major ATON structures, such as ranges, would depend on the specific operational requirements for the aid.
 6. WLIC Capabilities. Coast Guard construction tenders (WLICs) build most of the minor ATON structures in the East Coast and Gulf Coast regions, based on standard designs of the type shown on the data sheets at the end of this manual. However, WLICs could potentially construct more complex structures, if the designs could be made to fall within the capabilities of these vessels. Structure cost could possibly be reduced compared with construction by commercial contractors. Designers should therefore consider the capabilities of the WLIC fleet when developing ATON structure designs for areas where WLICs are available. WLICs typically have the equipment and skills necessary to drive vertical and battered piles made of wood, steel, or concrete. Limitations include the depth of water in which the piles are to be driven (generally a maximum of 20 feet for WLICs) and the length of pile that can be handled (normally, a 60-foot pile is the maximum length which can be driven in the water depths in which WLICs build aids). However, be aware that pile lengths may be controlled by commercial transportation restrictions on local roads. Depending on the nature of the design, special training, tools, and onsite engineering supervision may be required.
 7. Total Ownership Cost. ATON structures shall be designed to meet the operational requirements while minimizing the total ownership cost of construction and maintenance. Guidance on total ownership cost is available in the Shore Facilities Manual, COMDTINST M1100.13 (series).
 8. Climber Safety. Climber safety shall be a primary consideration in the design of ATON structures. Specifically, it is Coast Guard policy to comply with Occupational Safety and Health Administration (OSHA) standards with regard to ladders and fall protection devices on structures. Detailed guidance is provided later in this chapter.
- E. Structure Components. The following section describes general design requirements for the primary components of ATON structures.
1. Corrosion protection. Materials used on ATON structures (wood, steel, concrete, coatings) should be of a type suitable for long-term exposure to the marine environment. For major ATON structures, the use of cathodic protection systems should be considered on a case-by-case basis.
 - a. Wood. Wood members (piles, platforms, ladders) should be pressure-treated with a suitable preservative to extend their natural life. An exception would be if the structure is in a high knockdown area, and it can reasonably be expected that it will be destroyed by a collision within a year or less. In that case, untreated wood is

acceptable. Information on wood preservation is available from the American Wood-Preservers' Association (www.awpa.com). Keep in mind that wood preservation is a dynamic area with constantly changing regulations concerning environmentally-acceptable preservatives. When in doubt about the acceptability of a given preservative, consult the cognizant CEU for guidance.

- b. Steel. All steelwork should be coated to prevent corrosion, unless the structure is in a high knockdown area and it can reasonably be expected that it will be destroyed by a collision within a year or less. This coating can be in the form of galvanizing, or through the application of an appropriate paint system. Painting guidance is provided in the Coatings and Color Manual, COMDTINST M10360.3 (series). The Society for Protective Coatings is another source of information on coating industry practices (www.sspc.org). When using steel pipe piles, the interior should be filled with concrete or a steel cap welded to the top to prevent internal corrosion.

2. Foundations.

- a. Piles. The vast majority of ATON structures are built from piles, either single piles or multiple piles, which are driven into the bottom through a variety of methods. They support the structure platform by transmitting loads to the soil in which they are imbedded. Piles are usually made from one of the following materials: wood, steel pipe, steel H-beams, or precast concrete. When using steel pipe pile, the material should be straight seam or seamless--do not use spiral weld pipe. Other materials, including composites and plastics, may be considered for use on a case-by-case basis. The choice of which material to use for a given structure would be based on a number of factors, including the availability of the material in the required sizes; the nature of the bottom soil in which the piles will be driven; the comparative costs of the various options; the expected design life of the structure; and the capabilities of the platform and equipment available to drive the piles. A detailed discussion of pile foundation design and installation can be found in U.S. Army Field Manual FM 5-134, Pile Construction; U.S. Army Engineering Manual EM 1110-2-2906, Design of Pile Foundations; and U.S. Army Training Manual TM 5-849-1, Pile Driving Equipment. These manuals cover soil mechanics, the physical and performance characteristics of the different pile material types, and pile driving techniques, equipment, and safety procedures. Additional safety guidance related to pile driving operations can be found in 29 CFR XVII 1926.603 and 29 CFR XVII 1926.605.

- (1) Single Pile. A single-pile structure should normally be constructed if the minimum penetration required to achieve fixity can be attained. Since strength of the pile is not generally the critical factor, the type of pile should be selected on the basis of which has the lowest total ownership cost. In most locations, the resulting choice will be a wood pile. When using single wood pile structures in high knockdown areas, install the tethering system shown in the data sheet at the end of this manual. For moderate ice conditions or areas with very hard bottom types, single-pile steel structures are very effective. Concrete piles are generally not recommended unless it is determined that a wood pile would not penetrate the

specific bottom conditions or that steel is too costly or not easily obtainable. Single pile structures vibrate significantly and should not be used for sensitive electronic installations.

- (2) Multiple Pile. When the penetration required for fixity cannot be achieved, it may be necessary to use a multiple-pile structure. Multiple piles should also be used when there is a need to reduce vibration. The three common types of multiple-pile foundations are described below.
 - (a) Battered Pile Dolphin. A battered pile dolphin, which is very effective in soft bottom conditions, consists of three or more piles which are driven on an angle to the vertical (a "batter"). This is done in a symmetrical pattern with the piles spread at the bottom and bound together at the top with wire rope or securely fastened with bolts and shear connectors to make as rigid a joint as possible. Because the piles are battered and working with each other, the penetration required for each pile in this type of dolphin is normally two-thirds that required of a single pile in a soft bottom. If the dolphin is located in a high knockdown area, install the tethering system shown in the data sheet at the end of this manual.
 - (b) Cluster Pile Dolphin. A cluster pile dolphin consists of three or more piles all driven vertically, with their surfaces in contact with one another and wrapped tightly together at various heights. The penetration required for each pile in this type of dolphin is normally 25 percent greater than that required of a single pile in a soft bottom. If the dolphin is located in a high knockdown area, install the tethering system shown in the data sheet at the end of this manual.
 - (c) Platform Foundation. This type of foundation consists of three or more separate pilings which are driven vertically. The piles are connected by a pile cap that spreads the vertical and horizontal loads and any overturning moments to all the piles in the group. Cross bracings can be added to achieve a more rigid foundation. The majority of these structures are used as foundations for skeleton towers. The vertical dead load of the tower must, therefore, be considered in the design of the foundation. The penetration required for each of the piles for a platform structure should be the same as that required for a single-pile structure. Due to the critical nature of this type of structure, especially when used for ranges, penetration should not be reduced. The lateral spread between each of the vertical pilings must be less than the penetration of each pile. If the minimum required penetration cannot be achieved, at least 75 percent of the minimum required embedment must be achieved and cross bracing is required. For range structures located in areas subject to hurricanes, consider driving an additional "center" pile to mark the aid position in the event the structure is destroyed. Ensure that the top of the pile remains visible above mean high water. Since this pile is not a structural member, it should not be braced to the range structure. Tether the pile with

the system shown in the data sheet at the end of this manual to ensure that it remains on station if the range structure is destroyed. This will assist the servicing unit in finding the charted position for rebuilding the structure.

- b. Other Foundation Types. In addition to piles, other foundation types are commonly used for ATON structures. These would include posts, spindles, caissons, concrete footings, concrete slabs, steel stakes, and rip-rap.
3. Towers. Welding of towers shall be in accordance with American Welding Society (AWS) guidelines. Many ATON structures include modular skeleton towers available off-the-shelf in standard sizes from commercial sources. These shall be installed in accordance with the manufacturer's instructions. When towers are installed on the ground (vice on a platform), the legs of the tower shall be mounted in concrete footings. Tower legs shall **never** be placed directly into the soil.
4. Platforms. Platforms shall be designed to support all the equipment and servicing personnel that might be on the aid at one time, with a safety factor of four (assume servicing personnel to be a minimum of 200 pounds per person).
 - a. Railings. To prevent falls, a railing should be provided along the edges of all ATON structure platforms unless the configuration of the structure or the operational environment in a given location would make a railing impractical or unsafe. When provided, railings shall meet the requirements of 29 CFR XVII 1910.23. Ensure that solar panels are installed in such a way that the railing does not shade the panels.
5. Ladders. Fixed ladders should be provided on all ATON structures unless the configuration of the structure or the operational environment in a given location would make a fixed ladder impractical or unsafe. When provided, ladders shall meet the requirements of 29 CFR XVII 1910.27 and 29 CFR XVII 1926.1053. When the configuration of the structure will not allow the installation of a ladder with the ladder safety device described below, an alternative method of providing fixed anchorage to ensure climbers' safety is required.
 - a. Ladder Safety Devices. These devices are intended to reduce the possibility of accidental falls. In general, ladder safety devices should be provided anytime an ATON structure includes a fixed ladder. Exceptions would be if the configuration of the structure or its operational environment would make a ladder safety device impractical or unsafe. When provided, ladder safety devices shall meet the requirements of 29 CFR XVII 1910.27 and 29 CFR XVII 1926.1053. Rigid rail systems and cable systems are both acceptable, provided they meet the requirements of Federal Specification RR-S-001301.
6. Related Equipment.
 - a. Dayboards. Design requirements for dayboards are provided in the Aids to Navigation Manual - Technical, COMDTINST M16500.3 (series). A dayboard shall always be

installed in a position that gives it maximum utility. Where feasible, the dayboard should be the dominant component of the silhouette, with the battery box hidden behind it. Dayboards shall normally be installed vertically. When heavy bird fouling on the face of the dayboard is anticipated, it may be installed approximately 5 degrees from vertical, leaning toward the observer. Whenever possible, dayboards shall be mounted on an angle to the channel line. This angle will vary to best suit the particular channel, but for a straight channel line, it should be about 30 degrees. See Figure 1 below.

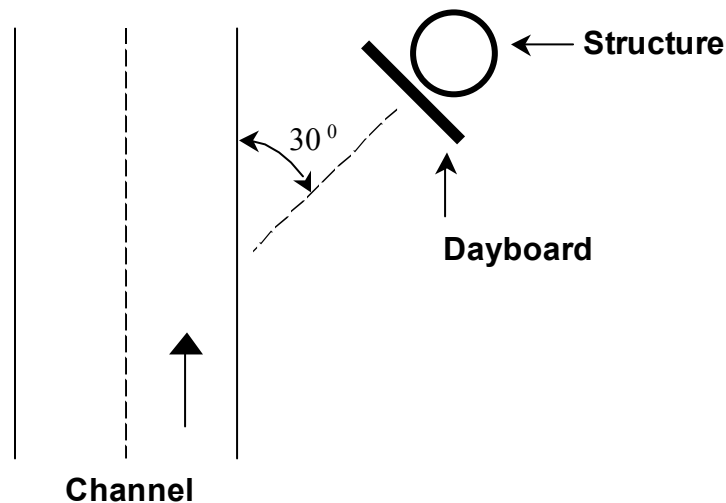


Figure 1 - Dayboard Mounting

This will make the numbers easier to read when the aid is nearly abeam. However, in some circumstances this is not practical, such as with "H" piles or square platforms, in which case the daymark should be mounted perpendicular to the channel line. The method of mounting dayboards is optional and at the discretion of the servicing unit. Nails, U-bolts, J-bolts, corner clamps, and edge clamps are commonly used for attachment. Fasteners shall not pierce the reflective borders or characters, but should penetrate the colored fluorescent films. The fastenings should be designed so that the dayboard becomes sacrificial in high winds.

- b. **Battery Boxes.** The standard battery box shown on the data sheet at the end of this manual is predrilled for a plastic stuffing tube, which shall be installed to keep the box watertight. The battery box shall be installed on the platform, in proximity to the lantern. Refer to the Aids to Navigation Manual - Technical, COMDTINST M16500.3 (series) for the maximum length of power cable allowed between the lantern and the battery box. In high knockdown areas, install the tethering system shown in the data sheet at the end of this manual. Lag screws or machine nuts and bolts are used to secure the battery box to the platform. When mounting the box, allowance should be made for drainage of water under it. The battery box has a snap

lid that is normally sufficient to secure the top. At the time of manufacture, however, four pilot holes are drilled through the lip of the battery box top--if necessary, four corresponding holes can be drilled through the lip of the bottom to further secure the top with nylon line. Plastic battery boxes shall not be used as lantern supports. Cables shall not be installed in the screen-covered air vent holes, which are essential for the operation of the batteries and must be protected from the entrance of vermin. The first failure of cable is often due to corrosion of the terminals. Therefore, when installing new lead-in wires, allow about one foot of extra wire inside the battery box. If the lugs or the wire at the terminal require replacement, the cable can then be trimmed a few inches and new lugs installed.

- c. Lanterns, Sound Signals, Solar Panels. Preparation and installation shall be as outlined in the Aids to Navigation Manual - Technical, COMDTINST M16500.3 (series).
- d. Radar Reflectors. The data sheet at the end of this manual details the construction of a lightweight dihedral radar reflector for use on structures. It shall be installed when the radar reflectivity of the structure without a reflector does not meet the operational requirements. The range of this reflector is 1.5 to 2.0 miles using a standard radar set, based on mounting the reflector 10 feet above water level. The reflector may be mounted by nailing or bolting it to the structure. It is very important that the angle between the plates be maintained at 90 degrees plus or minus one degree. It is also essential that the reflector be properly oriented to the channel, with the bisector of the angle between the plates (not the edge of a plate) pointed toward the user. This reflector shall not be used as a lantern stand since it is not strong enough to support a lantern. Where greater radar reflectivity is required, a larger reflector of similar design may be mounted either on the structure or below the lantern. If mounted below the lantern, the lantern leveling bolts shall be installed between the lantern stand and the radar reflector to allow the two components to be leveled simultaneously.

CHAPTER 3. INSPECTION

- A. General. Periodic inspection of ATON structures is required to ensure the safety of servicing personnel and to protect the Coast Guard's capital investment. These inspections are designed to ensure the structures meet their functional requirements; identify the need for corrective action before advanced deterioration necessitates major repairs; schedule maintenance on a planned basis rather than intermittently; and eliminate both over-maintenance and under-maintenance of the structures. Two levels of inspection are described in this chapter. The first level is called a "Scheduled Structural Inspection." Its purpose is to ensure that every ATON structure in the Coast Guard is visited on a regularly scheduled basis to assess the physical integrity of the structure and initiate action for repair or replacement if necessary. Depending on the nature of the structure (see below), this inspection is carried out either by an engineering professional (CEU representative) or a Coast Guard construction tender (WLIC). The second level is called a "Field Unit Maintenance Inspection." Its purpose is to provide ongoing monitoring of a structure's physical condition by ATON field units which visit the aid to service the signal equipment.
1. Shore Station Maintenance Record (SSMR). The SSMR, Form CG-4094, serves to identify, quantify, specify, request, and schedule repairs which are beyond the capability of servicing units and which must be accomplished by higher maintenance levels. SSMRs should be submitted to the cognizant CEU via the Group and District Commander (oan) if the condition of a given structure so warrants it, based on the inspections described below. The SSMR process is described in the Shore Facilities Manual, COMDTINST M1100.13 (series).
- B. Scheduled Structural Inspection. At least once every five years, every ATON structure in the Coast Guard shall be inspected to evaluate its structural integrity.
1. Inspection Requirements. At a minimum, this structural inspection shall result in the following:
 - a. A determination of whether the physical condition of the structure presents a safety hazard to servicing personnel who climb it.
 - b. A determination of whether the physical condition of the structure provides the required function of supporting the ATON equipment.
 - c. A compilation of deficiencies and recommendations for immediate and long-term action.
 - d. An estimate of the remaining service life of the structure.
 2. Responsibility for Inspection. The inspection shall be carried out by a CEU representative or a WLIC, as specified below.

- a. CEU. A representative of the cognizant CEU shall perform a structural inspection of every ATON structure in that CEU's geographic Area of Responsibility (AOR) that meet the criteria listed below. This representative shall be either an employee of the CEU or an individual contracted by the CEU to perform this function.
 - (1) Criteria for CEU Inspection. A CEU representative shall perform the inspection if a given ATON structure meets any one of the following criteria:
 - (a) It was designed by a commercial A/E firm.
 - (b) It was built by a commercial contractor.
 - (c) It was built by a Coast Guard asset (e.g., WLIC) based on a CEU design.
 - (2) Additional CEU Inspection. Each year, a CEU representative shall inspect a minimum of one percent of the structures in their AOR which meet the requirements of paragraph 3.B.2.b.(1) below. This is in addition to the basic inspection requirement described in paragraph 3.B.2.a.(1) above.
 - b. WLIC. The cognizant WLIC shall perform the inspection if a given ATON structure meets the criteria listed below.
 - (1) Criteria for WLIC Inspection. The WLIC shall perform the inspection if a given ATON structure is a standard design that is built repetitively by that unit in its AOR, with no direct input from the CEU on the design of that specific structure.
3. Documentation of Inspection. The activity which performed the inspection shall document the findings in a written report containing the following information:
- a. Name of the aid and its Aid Number.
 - b. Date of inspection.
 - c. Date of last scheduled inspection.
 - d. Planned date of next scheduled inspection.
 - e. Inspector's name, title, organizational affiliation, and contact information.
 - f. Brief description of the structure (type, height, location).
 - g. List of discrepancies identified and their potential impact on the function, serviceability, and service life of the structure. Note specifically those which pose an immediate safety hazard.
 - h. Recommendations for action.

- i. Estimate of the remaining service life of the structure.
 - j. Digital photographs showing the condition of the aid, with specific emphasis on any discrepancies found during the inspection.
4. Reporting Requirements. The results of the inspection shall be reported as described below. If the condition of the structure so warrants it, a CASREP message should be generated and/or an SSMR submitted as part of this reporting process.
- a. CEU. The documentation of inspection with recommendations for action shall be disseminated within the CEU in accordance with CEU-developed administrative procedures. A copy shall be provided to the cognizant District (oan).
 - b. WLIC. The documentation of inspection with recommendations for action shall be forwarded through the chain of command to the cognizant District (oan).
- C. Field Unit Maintenance Inspection. ATON field personnel play an important role in the inspection of ATON structures. The sheer number of structures Coast Guard-wide and their location in remote areas makes the attentive and properly trained eyes of field personnel essential tools for identifying defects and initiating corrective action in a timely manner. During each visit to an ATON structure, the servicing unit should perform the Field Unit Maintenance Inspection described herein. This is to ensure the structural integrity of an aid before climbing, and to identify and initiate corrective action for any needed repairs via the SSMR process. If the aid appears unsafe, **do not climb**. Generate a CASREP message and submit an SSMR to initiate repairs.
- 1. Inspection Guidelines. Detailed guidance for performing a Field Unit Maintenance Inspection is provided in Appendix A of this manual.
 - 2. Documentation of Inspection. Use the "Inspection Form" included in Appendix A to document the results of the inspection. Maintain a copy of this report in the aid folder.
 - 3. Reporting Requirements. If repairs to the structure are required that are beyond the capability of the servicing unit, the documentation of inspection with recommendations for action shall be forwarded through the chain of command to the cognizant District (oan). If the condition of the structure so warrants it, a CASREP message should be generated and/or an SSMR submitted as part of this reporting process. Include digital pictures showing the condition of the aid, with specific emphasis on any discrepancies found during the inspection.

CHAPTER 4. CLIMBING SAFETY

- A. General. Personnel safety is paramount for all those involved in climbing ATON structures of any height. No person should get hurt while servicing ATON.
- B. Climber Training. Personnel must complete formal, CEU-sponsored climber safety training before being allowed to climb ATON structures, regardless of the height of the structures involved. Currently, this training is available through a variety of mechanisms. In some Districts, the cognizant CEUs provide the training directly. In others, the CEUs have implemented a "train the trainer" format. While this describes the current situation, the program goal is to have a formal mechanism for climber training standardized throughout the Coast Guard. This is now being studied, and this manual will be updated to reflect the new mechanism when it is established. Regardless of the source of the training, successful completion should provide the prospective climber with knowledge of the following areas:
1. Recognition and avoidance of dangers.
 2. Inspection and use of personal fall arrest equipment.
 3. Use of personal protective gear and clothing.
 4. Procedures for safely ascending, descending, maneuvering, crossing, positioning, and working on structures.
 5. Rescue procedures.
- C. Requirements for Climbers.
1. Minimum Qualifications. The minimum requirements to qualify an individual to climb ATON structures are listed below.
 - a. The individual must be a responsible volunteer.
 - b. The individual must be physically capable.
 - c. The unit commander must recommend the individual.
 - d. The individual must have written certification to climb ATON structures. This certification shall be from the cognizant CEU, based on the individual's successful completion of climber training as described in paragraph 4.B above.
 2. Buddy System. Climbers shall use the buddy system. When climbing to a height of 150 feet or less, a safety observer is required on the ground. The observer should be stationed a suitable distance away from the structure base, preferably upwind, so that he or she always has a clear view of the climber. The safety observer shall be a qualified climber who meets the requirements of paragraph 4.C.1. The safety observer shall utilize all of

the safety equipment described in paragraph 4.D. The safety observer shall have constant two-way communication with the climber on the structure. When climbing structures greater than 150 feet in height, the safety observer shall join the primary climber on the structure and stay within 150 feet of the primary climber at all times.

D. Safety Equipment. All personnel engaging in construction, maintenance, repair or inspection shall use protective equipment and fall protection when working on any ATON structure.

1. Personal Protective Equipment (PPE). Safety precautions include the use of appropriate PPE (safety helmet, safety footwear, eye protection, protective clothing, and personal flotation device) to protect personnel from injury while in the vicinity of a structure. A safety helmet is required to be worn by any person within the "drop zone," which is an area whose radius is 1/2 the height of the structure and centered on the structure's axis.
2. Personal Fall Arrest System (PFAS). The climber must use a complete PFAS, which consists at a minimum of a full body harness, deceleration lanyard(s), and connecting device(s). Climbers shall be physically connected to a suitable anchorage on the structure at all times. Understand, know, and follow the maximum weight limits for your PFAS equipment. These limits are stated in the manufacturer's instructions. The working load limit is equal to the combined person and tool weight. Each piece of equipment shall be inspected for wear, damage, and other deterioration before each use, and defective components shall be immediately removed from service and destroyed. No part of a PFAS shall be used for other than its intended purpose. Never use this equipment for hoisting or towing. Do not use this equipment for recreational climbing. PFAS requirements are contained in 29 CFR XVII 1915.159 and 29 CFR XVII 1926.502, and are summarized below.
 - a. Full body harness. Full body harness must meet ANSI Z359.1-1992 requirements and must have a "D" ring which is centered in the wearer's upper back. The harness must be sized to the individual. The full body harness must be specifically rated for fall arrest.
 - b. Connecting Hardware. Connecting hardware must have double-acting or 2-step safety locks. Shackles, clevis, carabineers, and hooks are the four common hardware connecting devices. All connecting hardware must have a minimum tensile strength of 5,000 pounds and shall be proof tested to a minimum of 3,600 pounds.
 - c. Lanyards. Shock absorbing fall restraint lanyards (also called deceleration lanyards) must meet ANSI Z359.1-1992 and ANSI A10.14-1991. These devices limit free-fall to six feet. The shock absorbing portion of the lanyard must be attached closest to the wearer's body. The overall length of the lanyard is limited to six feet. Ropes, straps, and webbing used in lanyards, lifelines, and strength components of body harnesses shall be made from synthetic fibers. A safety lanyard shall be attached to all tools and equipment on the tower to prevent missile hazards.

- d. Anchorage. Anchorages are secure points of attachment for lifelines, lanyards, or deceleration devices, and are independent from the means of supporting the worker.
- 3. Ladder Safety Devices. When ascending or descending a fixed ladder, the climber shall use the ladder safety device whenever a given structure is so equipped. When structures are not equipped with ladder safety devices, or when the climber disconnects from the ladder safety device and no other fall protection is in place, the climber shall take care to maintain connection to suitable anchorages on the structure at all times.

E. Pre-Climb Safety Requirements.

- 1. Pre-Climb Planning. Note the following as it relates to climbing a given structure.
 - a. Any special equipment that will need to be acquired and any special training or training reviews that must be performed before work begins.
 - b. The skill and experience of each member of the crew assigned to perform the work.
 - c. The type of equipment that will be required and the individual worker's training and skill with that equipment.
 - d. Any special fabrication required for safety before work begins.
- 2. Evaluation of Potential Hazards. Before beginning climbing operations, evaluate the potential hazards that could impact on climber safety. These would include (but not necessarily be limited to) the following:
 - a. Weather related, such as wind, snow, ice, moisture, lightning, and sunshine. The structure should not be climbed in inclement weather, when electrical storm activity is forecast, or when fog obscures the portion of the structure to be climbed. In locations where fog is usually present and where unacceptable delays would result while waiting for the fog to dissipate, the structure may be climbed provided the climber and safety observer are equipped with reliable two-way radios. Radio checks should be initiated at least every 5 minutes.
 - b. Electrical dangers.
 - c. Noise.
 - d. Live hazards, such as snakes, birds, insects, rodents, farm animals, other humans.
 - e. Conditions related to non-standard structures.
- 3. Emergency Preparedness. Be aware of the following as they relate to the site in question.

- a. The emergency services available near the site and whether they could find the site in a timely manner. Question rescue services to establish that they have the equipment, skills, and response time to rescue a climber in the expected environment. These services should be given directions to the site.
 - b. The location of the nearest medical facilities. Every member of the crew should have access to a route map.
 - c. The phone numbers of emergency facilities, accessible to all members of the crew. Work at remote locations will require use of cell phones or a means of positive communications.
 - d. The familiarity of each climber regarding the location and operation of any rescue equipment and location of a first aid kit.
4. Pre-Climb Structural Inspection. Prior to climbing an ATON structure, it is critical to ensure it is actually safe to climb. Use common sense. If a structure appears unsafe to climb, **do not climb it**. Take corrective action if possible, or initiate a CASREP message and suspend servicing of the structure until safe conditions are restored. Appendix A provides comprehensive guidance on what to look for when assessing the condition of an ATON structure.
- F. Conditioning and Mechanics of Climbing. Personal condition is as important as the safety equipment. For safety, you will need physical well-being, emotional conditioning, a well-rested mind and body, and self-confidence. Get plenty of sleep and eat sensibly. Keep your fluid intake adequate.
1. Ascending/Descending. Climbing is a physical process and requires practice to do it correctly. Climbing is not a race. Your goal is to arrive at your work location comfortable, relaxed, and ready to work.
 - a. No one should stand around the base of a structure while a person is ascending, descending, or working.
 - b. Use of a safety climb device requires that you keep three points of contact with the structure. Do not jump or hop.
 - c. Climb with your legs, not your arms.
 - d. On tapered structures, climb on the high side or side that allows the climber to naturally lean into the structure.
 - e. Legs lead on the climb, arms lead on the descent.
 - f. Rest often and use rest platforms when they are available.

g. Keep body swing to a minimum.

2. Maneuvering. Climbing and maneuvering on ATON structures uses body mechanics that predominately involves the use of the arms and legs. "Look before you leap". Before undertaking any physical maneuver, consider carefully what you are doing. When suspending or descending, use approved descent equipment. If you are in doubt as to how to reach a particular location on the structure or how to perform the task in a location, consult other team members and your supervisor. Consider different physical actions and select the one that best suits your skill, strength, condition, and experience.
3. Crossing and Positioning. Before exiting a safe climb device, you must determine the need for fall protection. You must be continually aware of the location of other climbers and their anchorage points. Pay particular attention to attaching to diagonal structures or members. Remember that the connector will slide down diagonal structures. During the cross to a work area you must maintain 100 percent fall protection, which generally means 100 percent connection to the structure. The 100 percent connection rule is as effective as your attitude. If you are tired or tense, stop and connect with your lanyard and rest. Climbers are exerting physical energy and can often become over-fatigued. When you are tired, cold, hungry, cramped, or distracted, you are not safe.
4. Working on a Structure. Select a proper structure and wrap your positioning lanyard around the structure so it allows movement of your hands sufficient for the task. A rule of thumb is hold your elbow at your waist and move your arm up and down from chin to lap. If you do not contact the structure, the distance is correct. Be sure that the lanyard is connected and properly locked. **Never trust the sound of the hook or connector.** Visually sight your hardware and ensure that it has closed and is locked. Do not attach safety lanyards to guard rails, hoists, platform gratings, lighting equipment, or any loose equipment on the structure.

G. Rescue. There are five generally accepted rescue techniques, as listed below. Each of these techniques requires specific training and equipment. These techniques must be practiced on a recurring basis, and as such, are considered an integral part of structure climbing training.

1. Manual rescue. Reaching a fallen worker from the structure and pulling him or her back to the safety of the structure.
2. Outside Services. Professional rescue services should be used when available and if the response time is adequate.
3. Winch Rescue. If a winch is available and rigged, or can be rigged, attach an injured worker to the winch line and lower the victim to the ground.
4. Ascending/Descending Systems. These are manually operated devices that are appropriate to many climbing environments and to one-rescuer operation.

5. Approved Suspension Systems. This is an approved descent and suspension device that can be used to reach a fallen climber and assist the climber to the ground.



AIDS TO NAVIGATION MANUAL - STRUCTURES

APPENDIX A

GUIDELINES FOR FIELD UNIT MAINTENANCE INSPECTION

**COMDTINST M16500.25
AUGUST 2003**

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SECTION 1 - INTRODUCTION



General

The purpose of this Appendix is to provide guidance for field personnel to assess the condition of ATON structures when they visit the aids to service the signal equipment and systems. The goal is to ensure the structural integrity of the aid before climbing, and to identify and initiate corrective action for any needed repairs via the SSMR process. When evaluating the condition of a structure, the following questions should be addressed:

- What is wrong (description and scope)?
- Where is the problem (location)?
- How big is the problem (quantity)?
- When should it be fixed (priority)?

This Appendix provides guidance on what to look for to answer these questions, and includes an Inspection Form for field personnel to fill out and document their findings. This Appendix is divided in several sections, each of which addresses a particular aspect of structures. Each section includes figures and photographs to illustrate the conditions described, and provides checklists to assist field personnel in carrying out the inspections. These checklists are repeated in a condensed version on the Inspection Checksheet at the end of this Appendix for ease of reference during the inspection.

When carrying out these inspections, **do not climb** if an aid appears unsafe. Generate a CASREP message and submit an SSMR to initiate repairs.

Inspection Tools

Have the following items ready for use during the inspection:

- Flashlight

- Digital camera
- Hammers or pick for removing corrosion scale and sounding of structural members
- Shovel, hoe or ice chopper for removing marine growth
- Tape measure
- 2-foot or 4-foot level
- Clipboard and writing instrument
- Sounding line for measuring water depth
- Binoculars
- Wire brush
- Personal Protective Equipment (safety helmets, protective clothing, personal flotation devices)

Preliminary Information for the Inspection

Prior to the inspection, gather the following information as it pertains to the structure in question:

- As-built drawings, photographs, and previous inspection reports.
- Current speed at the structure. Inspect during slack conditions, if possible.
- Tidal range at the structure. Inspect during low or extreme low tide to maximize the area available for inspection. See Figures 1-1 and 1-2.
- Previous water depths and potential for seabed/riverbed scour.
- Other conditions: ice, floating debris, large waves, etc.

Overall Assessment Standards

The following terms should be used to describe the overall condition of the structure when completing the Inspection Form at the end of this Appendix.

- Good. No problems or only minor problems noted. Structural elements may show some very minor deterioration. Structure fully functional.
- Satisfactory. Minor to moderate defects and deterioration observed. Structure fully functional.
- Fair. All primary structural elements are sound, but minor to moderate defects and deterioration observed. Localized areas of moderate to advanced deterioration may be present but do not significantly reduce the function of the structure.

- Poor. Advanced deterioration observed on widespread portions of the structure. Movement of the structure has compromised the function of the aid. Unit should photograph and submit an SSMR.
- Critical. Very advanced deterioration or breakage has resulted in localized failures of primary structural components. More widespread failures are possible or likely to occur. Unit should photograph and submit an SSMR, and initiate a CASREP if necessary.

Arrival Checklist

The following are things to look for at "first glance" when arriving at the structure. The intent is to get an overall impression of the structure's condition, and to ensure the structure is safe to climb before proceeding with the complete Field Unit Maintenance Inspection.

- Ladders. Check ladders for corrosion, broken, bent or missing rungs, loose or failed connections, and malfunctioning fall arrest systems. Is the ladder misaligned? Does the ladder vibrate or move from the current, waves, or when the boat berths against it? Inspect welds for signs of corrosion, cracking, or breakage. If the ladder has been deformed from an impact, then adjacent welds on rungs and mounting brackets may have been cracked. See Photo 1-1.
- Steel members. Check the extent of steel member corrosion in the splash zone. Hammer the surface corrosion (use safety glasses) to remove corrosion byproducts and expose the steel below. Corrosion scale in the splash zone is a hard-layered, rust-colored build-up that swells to about ten times the thickness of the lost steel, often traps water inside, and may hide severe corrosion pitting or holes. Under the hard corrosion scale it is typical to find a layer of black paste-like oxide, just above the pitted gray steel surface. On a 30 to 40 year old structure, the splash zone corrosion scale may be 3/4" to 1" thick. Removal of the corrosion scale does not effect the structural integrity, and may expose severe corrosion defects.
- Connections. Check for bolt corrosion or loosening of bolts as indicated by wear marks from moving members, misalignment of mating surfaces, and by looseness or distortion of structural members. Loose bolts will typically move when hit with a hammer. Standard steel flat washers often will corrode quickly in a marine environment, which may loosen the bolt. If bolt washers move, then there is no tension in the bolt to clamp the fastened members together.
- Alignment. Check horizontal and vertical alignment. Is the fixed aid structure out of plumb? Do any of the piles appear bent or misaligned? See Photo 1-2.
- Bottom Scouring. Is the water under the structure deeper than originally designed, or deeper than reported at the previous inspection?

- Movement. Does the structure vibrate or move when the boat berths against it?
Does the structure deflect from wind gusts or waves?
- Impact/Collision Damage. Are there signs of damage caused by vessel impact, ice, logs, or other debris?

Figures

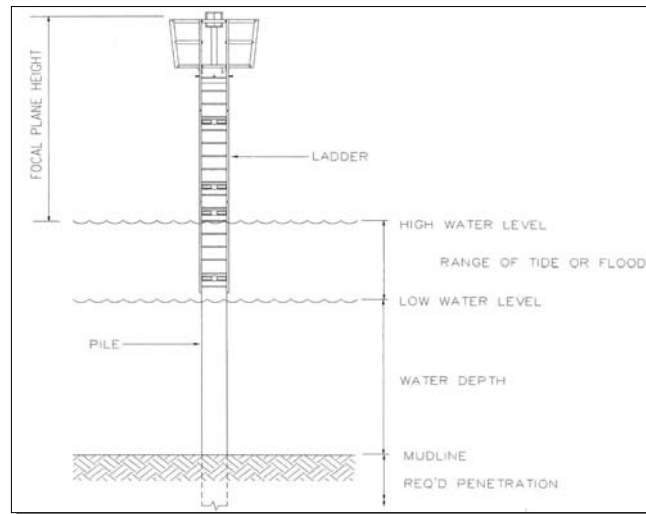


Figure 1-1 - Standard Single-Pile Fixed Aid with 5'x5' ATON Platform

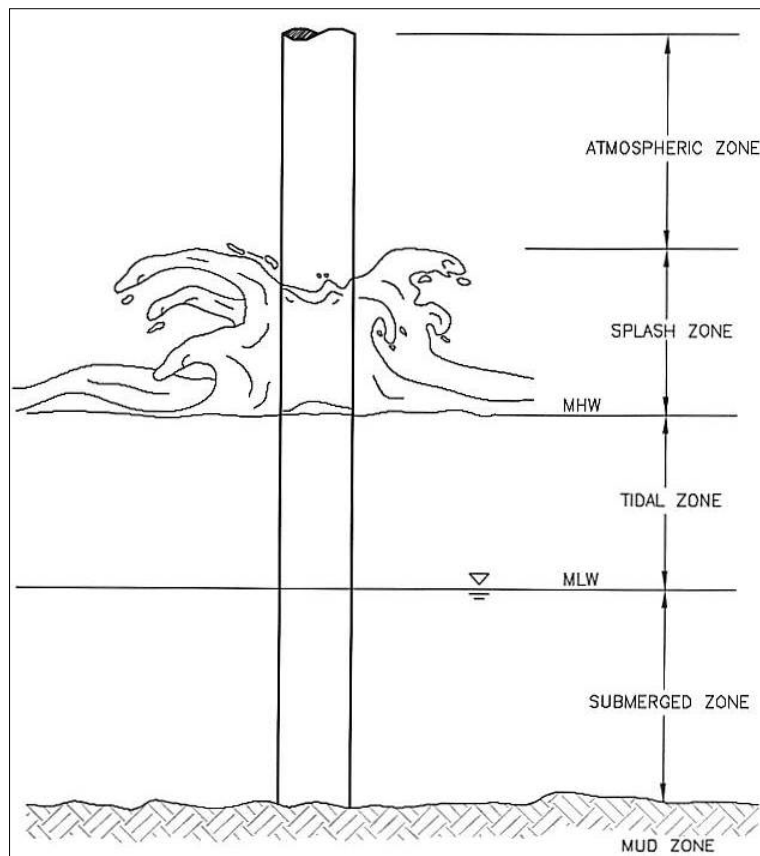


Figure 1-2 - Exposure Zones on Piling

Photos



Photo 1-1 - Bent Ladder



Photo 1-2 - Misalignment

SECTION 2 - TIMBER



General

Timber members have traditionally been used for construction and maintenance of aid structures due to their availability, economy, and ease of handling relative to other construction materials. Timber damage is caused by:

- Fungal rot/decay (see Figure 2-1).
- Marine borer and insect attack (see Figure 2-2).
- Connector corrosion and bolt loosening.
- Abrasion (see Figure 2-3).

Inspection Checklist

- a. Check the tops of piles for physical damage, dry rot, and termite or pest infestation and determine the depth of deterioration. See Photo 2-1.
- b. Check for cracked, rotted, loose, or worn piles or connecting braces. See Photos 2-2 and 2-3.
- c. Check pile and mast alignment. If the aid is a multi-pile structure, are the piles angled toward each other evenly? Is the mast out of plumb? See Photo 2-4.

- d.** Visually examine piling in the tidal zone for marine borer damage. The tidal zone is the area between high and low tide and is likely to be the most damaged. See Photos 2-2 and 2-5.
- e.** Sound the piles with a hammer and carefully probe with a thin-pointed tool such as an ice pick to look for internal decay and soft timber.
- f.** Check for member damage due to overload or impact. See Photo 2-6.
- g.** Clear a section of the structure of all marine growth and visually inspect for surface deterioration.
- h.** Check for corrosion of steel fasteners, including bolts, drift pins, and wire rope. Steel fasteners embedded in wet timber usually corrode faster inside the timber, which may not be apparent from visual inspection. Strike the bolt ends with a hammer to check for internal corrosion failure. Wire rope is often used to wrap timber pile cluster structures to hold the pile heads together. This wire rope typically corrodes internally at a faster rate than externally and may be structurally compromised even when the exterior of the wire appears only lightly corroded.

Condition Rating

Use Figure 2-4 to determine the overall condition rating of timber piles, and indicate this on the Inspection Form at the end of this Appendix.

Figures

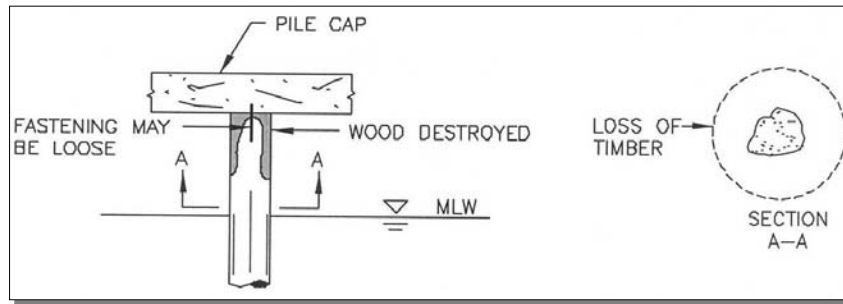


Figure 2-1 - Typical Rot and Fungi Damage to Timber Piles

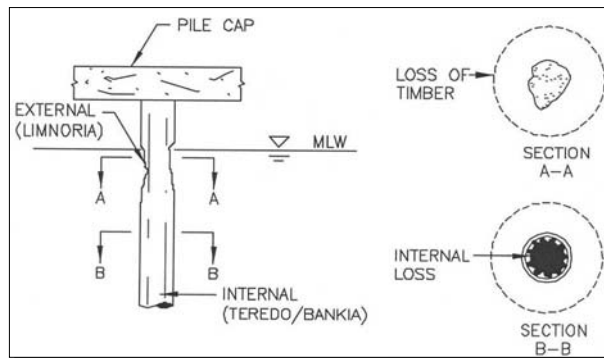


Figure 2-2 - Typical Marine Borer Damage to Timber Piles

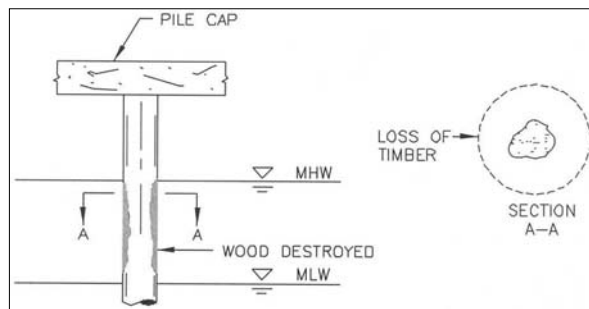

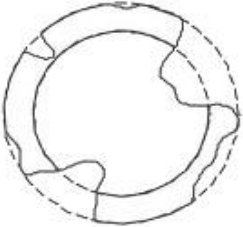
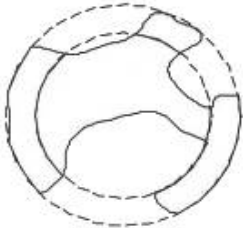
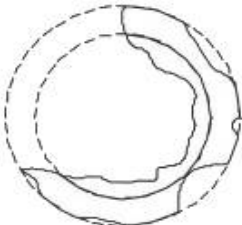


Figure 2-3 - Typical Abrasion Damage to Timber Piles

Figures (cont.)

TIMBER PILES

TIMBER PILE	
<u>CONDITION</u>	<u>RATING</u> <u>EXPLANATION</u>
NI	NOT INSPECTED, INACCESSIBLE OR PASSED BY
1	NO DEFECTS: <ul style="list-style-type: none"> - Less than 5% lost material - Sound surface material - No evidence of borer damage
	2 MINOR DEFECTS: <ul style="list-style-type: none"> - 5-15% lost material - Sound surface material - No evidence of borer damage - Minor abrasion damage
	3 MODERATE DEFECTS: <ul style="list-style-type: none"> - 15-45% lost material - Significant loss of outer shell material - Evidence of borer damage - Significant abrasion damage
	4 MAJOR DEFECTS: <ul style="list-style-type: none"> - 45-75% lost material - Significant loss of outer shell and interior damage - Evidence of severe borer damage - Severe abrasion damage
	5 SEVERE DEFECTS: <ul style="list-style-type: none"> - More than 75% lost material - No remaining structural strength - Severe borer damage

NOTE: Explanation of defect should be placed in the comments column.

Figure 2-4 - Condition Rating of Timber Piles

Photos



Photo 2-1 - Fungal Rot of a Timber Pile



Photo 2-2 - Marine Borer Deterioration of Bracing and Pile in the Tidal Zone

Photos (cont.)



Photo 2-3 - Deterioration of Longitudinal Wale



Photo 2-4 - Structure Alignment Problem

Photos (cont.)

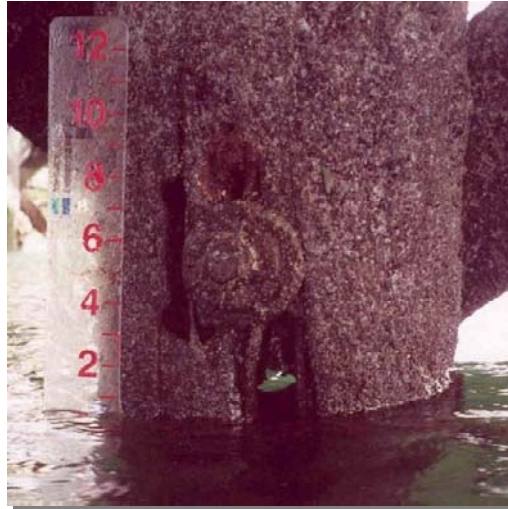


Photo 2-5 - Marine Borer Damage at Bolt Hole

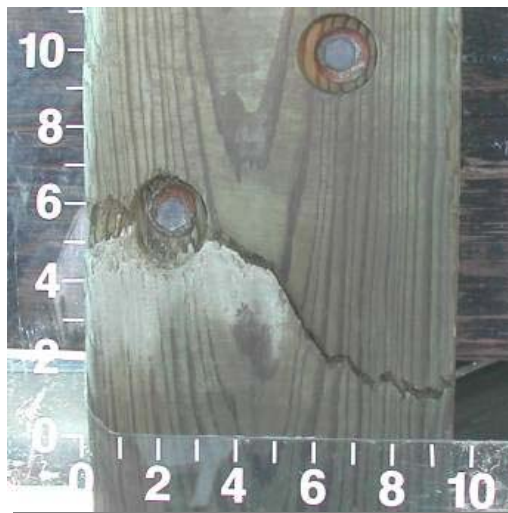


Photo 2-6 - Impact damaged timber

SECTION 3 - STEEL



General

Steel is used in the construction of ATON structures due to ease of connection, fabrication, and splicing, ductile behavior, and the ability to drive steel piles through hard soil. There are six major types of steel structure deterioration to watch for in the marine environment:

- Corrosion and coating loss (see Figure 3-1).
- Abrasion.
- Loosening of structural connections, missing bolts.
- Fatigue (broken or cracked welds).
- Overloading.
- Loss of foundation material.

Inspection Checklist

- a. Check for corrosion evidence: rust, scale, and holes, especially in the splash zone and at extreme low water level. See Photos 3-1, 3-2, and 3-3.
- b. Check the extent of steel member corrosion in the splash zone. Hammer the surface corrosion (use safety glasses) to remove corrosion byproducts and expose the steel below. See Photo 3-4.

- c. Check for deformation, distortion, or deflection. See Photo 3-5.
- d. Check for abrasion of steel structures as indicated by a worn, smooth, or polished appearance.
- e. Inspect welds for signs of corrosion, cracking, or breakage. See Photo 3-6.
- f. Inspect coating for any peeling, blistering, etc. See Photo 3-7.
- g. Check for loss of foundation material and/or scour.

Condition Rating

Use Figure 3-2 to determine the overall condition rating of steel piles, and indicate this on the Inspection Form at the end of this Appendix.

Figures

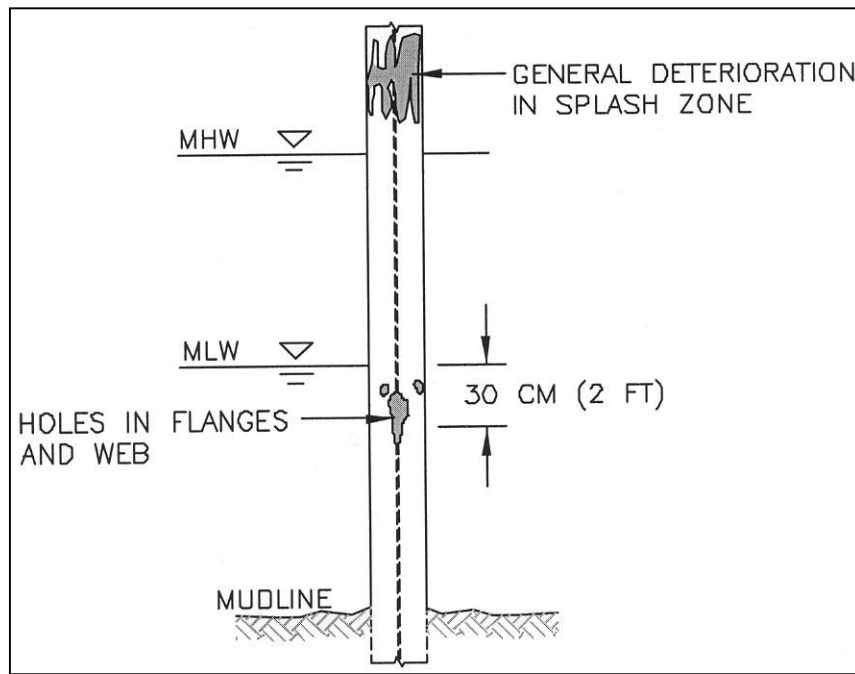


Figure 3-1 - Advanced Corrosion in Steel H-Pile

Figures (cont.)

STEEL PILES

STEEL PILE	
<u>CONDITION</u>	<u>RATING</u> <u>EXPLANATION</u>
NI	NOT INSPECTED, INACCESSIBLE OR PASSED BY
1	NO DEFECTS: <ul style="list-style-type: none">– Sound surface material– Less than 10% coating deterioration– No evidence of surface rust or pitting
2	MINOR DEFECTS: <ul style="list-style-type: none">– Light surface rust– 10–20% coating deterioration– Light pitting
3	MODERATE DEFECTS: <ul style="list-style-type: none">– Rust that is loose and flaking with some pitting– Scaling can be removed with some effort by the use of a scraper or chipping hammer– Element exhibits measurable but not significant loss of section
4	MAJOR DEFECTS: <ul style="list-style-type: none">– Widespread coating deterioration– Scaling removal requires increased effort by use of a scraper or chipping hammer– Element exhibits increased loss of section
5	SEVERE DEFECTS: <ul style="list-style-type: none">– Heavy, stratified rust or rust scales with extensive pitting– Removal requires exerted effort and may require mechanical means– Significant loss of section

NOTE: Explanation of defect should be placed in the comments column.

Figure 3-2 - Condition Rating of Timber Piles

Photos



Photo 3-1 - Severe Corrosion at MLW



Photo 3-2 - Diagonal Bracing, Corrosion Hole

Photos (cont.)



Photo 3-3 - Severely Deteriorated Wale (Note knife edge flange)



Photo 3-4 - Severely Corroded Steel Framing

Photos (cont.)



Photo 3-5 - Vessel Impact Damage to a Fixed ATON Structure



Photo 3-6 - Broken Weld

Photos (cont.)



Photo 3-7 - Coating Deterioration in the Splash Zone

SECTION 4 - CONCRETE



General

Reinforced concrete is a construction material for ATON structures due to its relatively low cost and durability. The durability of concrete in the marine environment is highly dependent on the quality of concrete mix used. It is not unusual to find relatively new concrete structures in poor condition, while adjacent older structures are in better condition. Deterioration of concrete appears in the following forms:

- Corroded steel reinforcing (see Figure 4-1).
- Abrasion wear, which is usually only significant in poor quality concrete (see Figure 4-2).
- Chemical deterioration accelerated by continuous exposure to saltwater, causing soft friable concrete (which can be pulled apart by hand or with hand tools), or spalling and/or cracking with rust stains, which usually indicates the reinforcing steel is corroding.
- Overloading damage as noted by cracking, spalling, or concrete breakage.
- Shrinkage cracking.

Inspection Checklist

a. Inspect for cracks, spalling, corrosion of reinforcing steel, and visual signs of rust staining. Solid reinforcing bars are much more tolerant of corrosion than are prestressing strands (embedded high strength wire cable). See Photos 4-1, 4-2, and 4-3.

b. Check for evidence of chemical deterioration, abrasion wear, and overload damage. See Photo 4-4.

c. Sound the piling with a hammer to detect any loose layers of concrete or delaminations.

- A sharp ringing noise indicates sound concrete.

- A soft surface will be detected, not only by a sound change, but also by the change in rebound, or feel, of the hammer.

- A thud or hollow sound indicates a delaminated layer of concrete, most likely due to the corrosion expansion of internal reinforcing steel. Loose delaminated concrete may be removed to inspect the extent of reinforcing corrosion below.

Condition Rating

Use Figure 4-3 to determine the overall condition rating of concrete piles, and indicate this on the Inspection Form at the end of this Appendix.

Figures

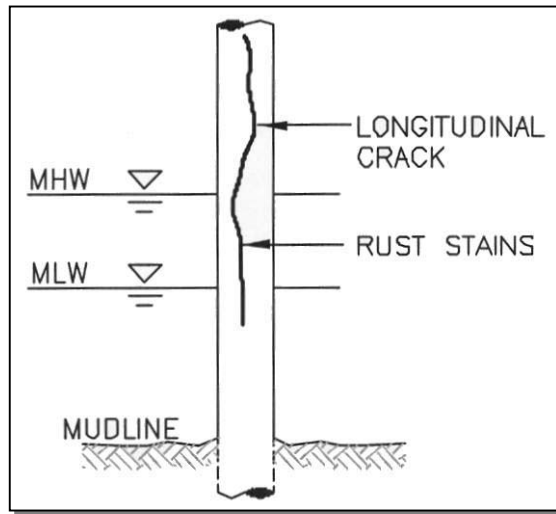


Figure 4-1 - Typical Corrosion Damage to Concrete Piles

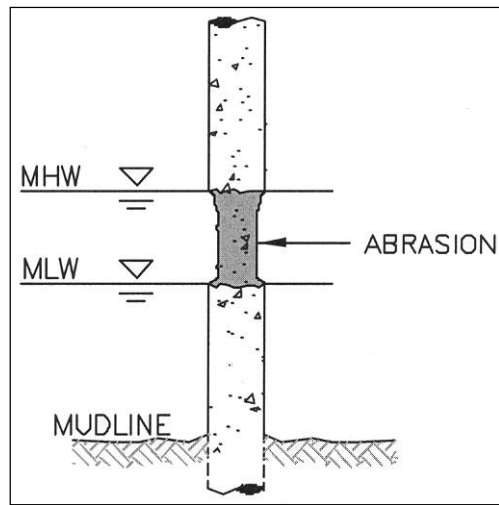


Figure 4-2 - Typical Abrasion Damage to Concrete Piles

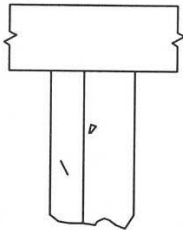
Figures (cont.)

CONCRETE PILES

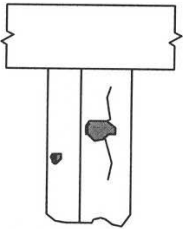
CONCRETE PILE
CONDITION RATING EXPLANATION

NI NOT INSPECTED, INACCESSIBLE OR PASSED BY

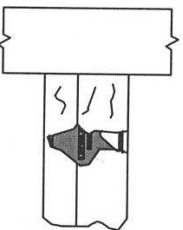
- 1 NO DEFECTS:
- Hairline cracks
 - Good original surface, hard material



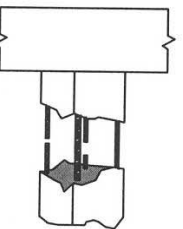
- 2 MINOR DEFECTS:
- Good original surface
 - Minor cracks or pits
 - Small chips or popouts
 - Slight rust stains
 - Hard material, sound
 - Corrosion of the wires



- 3 MODERATE DEFECTS:
- Limited spalling of concrete
 - Minor corrosion of exposed re-bar
 - Rust stains along re-bar
 - Softening of concrete
 - Reinforcing steel ties exposed
 - Popouts or impact damage



- 4 MAJOR DEFECTS:
- Spalling of concrete results in (10-15%) loss
 - Large spalls six inches or more in width or length
 - Deep wide cracks along re-bar
 - Major rust stains along re-bar
 - Wide spread surface disintegration



- 5 SEVERE DEFECTS:
- Exposed re-bar with 50% loss of steel section area
 - More than 15% loss of concrete

NOTE: Explanation of defect should be placed in the comments column.

Figure 4-3 - Condition Rating of Concrete Piles

Photos



Photo 4-1 - Rust Staining of Concrete Pile



Photo 4-2 - Vertical Crack and Spall

Photos (cont.)



Photo 4-3 - Vertical Cracking in Tide Zone



Photo 4-4 - Failed Repair with Exposed and Corroded Reinforcing

SECTION 5 - OTHER CONSTRUCTION MATERIALS

General

In addition to timber, steel, and concrete, other types of materials may be incorporated in ATON structures. These include stone masonry, aluminum, fiberglass, plastics, and rubber. This section describes the common signs of deterioration in these materials, and provides checklists for use in the Field Unit Maintenance Inspection.

Masonry

Stone masonry structures can be built using many different types of stone block configurations and using irregular or rectangular cut stone blocks (see Photo 5-1). Precast concrete block masonry is typically built using rectangular blocks which may or may not be reinforced. The blocks may be connected with iron or steel dowels or large "staples," and the corrosion of the connecting dowels may allow blocks to fall out of the structure. The joints between blocks may be left open (called dry masonry construction) or may be mortar filled (pointed joints).

- a.** Check for missing or displaced blocks, usually due to mortar deterioration, loss of wedging stones, or corrosion of iron/steel dowels between blocks.
- b.** Check for wall movement, usually noted by a portion of the masonry structure having vertical and/or horizontal misalignment which varies from the design drawings or adjacent portions of the structure. Is a portion of the originally straight wall bowing outward? Has a portion of the structure settled?

Aluminum

The use of aluminum in ATON structures is usually for secondary portions of the structure, such as platforms, marker masts, solar panel mountings, and guard railings.

- a.** Check for corrosion, particularly if the aluminum is in direct contact with steel, concrete, or mortar. Aluminum should be separated from these other materials, typically using plastic spacers.
- b.** Check for abrasion and wear. Aluminum is much softer than steel, and will wear if subject to rubbing with other objects.
- c.** Check for cracked welds. The welded connections on aluminum structures are prone to cracking (see Photo 5-2).

Fiberglass

Many structural shapes, ladders, and gratings are available in fiberglass composites which can be well suited to ATON structures.

- a.** Check for broken members. Fiberglass is prone to impact damage, particularly in extremes of hot and cold weather and with aging after prolonged UV exposure.
- b.** Check for loose connections. Fiberglass members are usually connected together using stainless steel bolts, which can loosen over time.
- c.** Check for damage to the surface finish. Weathering and ultraviolet light (UV) can degrade the surface finish, which can cause fiberglass splinters to develop and present a hazard for servicing personnel.

Plastics

Various grades of polyethylene plastics are used in ATON structures. These may be in the form of sheets attached to the boat fendering of the structure, or polyethylene plastic piles and dimension "lumber", with or without internal reinforcing. The internal reinforcing is now mostly fiberglass rebar or fibers, though internal steel reinforcing has been used as well.

- a.** Check for broken or damaged members. Plastic are prone to impact damage, particularly in extremes of hot and cold weather and with aging after prolonged UV exposure.
- b.** Check for cracking. This can result from the manufacturing process itself, or by corrosion of embedded reinforcing steel.
- c.** Check for loose bolted connections.

Rubber

There are several types of rubber that are often used in boat fendering on ATON structures. The rubber will degrade over time after prolonged UV, ozone, and petroleum exposure. Ozone and UV will result in a hardened surface and rubber cracking with age. Petroleum exposure will swell and soften many types of rubber. The rubber deterioration should be monitored with each inspection, and the parts replaced when damaged.

- a.** Check for rubber deterioration--hardening, cracking, swelling, softening.

Photos



Photo 5-1 - Stone Foundation Aid



Photo 5-2 - Cracked Weld

SECTION 6 - LADDERS



General

Ladders are common to all types of ATON structures. Ladders are vital for servicing personnel to access the structure, and must be maintained in a safe condition. **Do not climb a ladder if it appears unsafe.**

Inspection Checklist

- a. Check horizontal and vertical alignment. Is the ladder misaligned?
- b. Does the ladder vibrate or move from the current or waves, or when the boat berths against it?
- c. Are there signs of damage caused by vessel impact, ice, logs, or other debris?
- d. Check ladders for corroded, broken, bent, or missing rungs.
- e. Check for corroded, loose, or failed connections. Loose bolts can be indicated by wear marks from moving members, misalignment of mating surfaces, and by looseness or distortion of the ladder. If bolt washers move, then there is no tension in the bolt to clamp the fastened members together.
- f. Inspect welds for signs of corrosion, cracking, or breakage. If the ladder has been deformed from an impact, then adjacent welds on rungs and mounting brackets may have been cracked.

- g.** Inspect the ladder safety device to ensure the safety rail is properly mounted on the tower. The rail sections should be installed right-side up (notches are at the bottom of the tapered cuts vice the top). Look for worn, broken, or defective notches.
- h.** Check the ladder safety device to ensure the sliders ride freely on the rail.
- i.** Inspect the clamps, studs, bolts, and nuts which secure the safety rail to the ladder for corrosion, looseness, and breakage
- j.** Ensure that the top of the safety rail is capped with a through bolt or other device that prevents the removal of a slider from the top of the rail.
- k.** Ensure that the safety rails are not be painted, as this will cause problems with the passage of sliders. Rails may be wire brushed and spray galvanized if necessary.

SECTION 7 - OTHER COMPONENTS

General

Additional checklists are provided below for structure components not covered in the other sections of this Appendix. Components not listed here, but found on specific structures, shall be inspected to ensure that they are capable of continuing to perform their intended function safely.

Platform

- a.** Inspect the platform decking or grating for structural integrity and soundness.
- b.** Check the railings for deterioration and parts that are broken, severely bent, or otherwise considered unsafe.

Tower

- a.** Visually inspect all structural members (i.e., diagonal, vertical, and horizontal steel members) and connections of the towers for evidence of corrosion, deformation, signs of fatigue, and differential movement.
- b.** Look for excess corrosion at the bolts and joints that are bolted together, and for missing, loose, or damaged bolts.
- c.** Check the plumb (straightness) of the tower. All towers must be plumb (straight up and down). A simple gross inspection is sufficient. If the tower looks crooked, use your thumb as a sight and be sure it is not an optical illusion. You may even find towers that zig zag. Improper construction or damage at specific section connections can cause one section of the tower to be out of plumb with the rest of the structure. Question any unexplained distortion. If the tower is leaning, something is wrong. Find out why it is leaning.
- d.** On hollow rod constructed towers, rust damage will not be as obvious. Each member of such a tower should have drain holes at the bottom to prevent water from collecting and causing damage. Check these drain holes to make sure they are not obstructed and are doing their job. The amount of rust flaking or leaking out can be an indication of the extent of the rust damage inside the hollow member.

Concrete Foundations

- a.** Inspect the concrete foundation above grade for signs of cracking or spalling. If conditions of the above grade concrete are poor, an area adjacent to the foundation should be excavated to check the condition of the concrete below grade.
- b.** Inspect the soil surrounding the tower foundation for evidence of settlement or upheaval.
- c.** Inspect the anchor bolts connecting the concrete foundation to the steel tower for deformation, loose nuts, corrosion, or defects.

Guy Anchors and Hardware

- a.** Inspect guy anchors, turnbuckles, thimbles, shackles, preformed dead end guy grips, shear pins, and cotter pins for signs of corrosion, deformation, and fatigue.
- b.** Preformed guy grips should be checked to ensure there is no change in surface appearance of the guy strand immediately next to these grips. A change in surface appearance may indicate slippage.
- c.** Ensure turnbuckles are properly moused with safety wire to prevent loosening of the turnbuckles. Also, turnbuckle threads should be coated with a light coat of petroleum based grease to prevent their binding.
- d.** Inspect structural guys for signs of bird caging, corrosion, fatigue, deformation, and broken strands. In weather conditions where there is no wind, a slack guy wire can be an indication that something is wrong.
- e.** Make sure that all safeties are installed and check the anchor where it enters the ground for corrosion.

Signal and Power Equipment

Items such as dayboards, battery boxes, wiring, solar panels, lighting equipment, sound equipment, and radar reflectors shall be inspected in accordance with the Aids to Navigation Manual - Technical, COMDTINST M16500.3 (series); the Alternating Current Aids to Navigation Servicing Guide, COMDTINST M16500.17 (series); and/or the Short Range Aids to Navigation Servicing Guide COMDTINST M16500.19 (series), as applicable.

INSPECTION FORM

Date of Inspection	Aid Name/Aid Number
Inspector (name, rank, unit)	Description of Structure (type, height, location)
Overall Assessment (circle one): Good Satisfactory Fair Poor Critical <div style="text-align: center; margin-top: 5px;">(For a definition of these terms, see page 2 of Appendix A)</div>	
Overall Comments:	
SSMR Submitted? Y N	
Structure Components	
<u>Timber Piles</u>	Condition Rating (circle one): NI 1 2 3 4 5 <div style="text-align: right; margin-top: -10px;">(See p. 10 of Appendix A)</div>
Comments:	
<u>Steel Piles</u>	Condition Rating (circle one): NI 1 2 3 4 5 <div style="text-align: right; margin-top: -10px;">(See p. 17 of Appendix A)</div>
Comments:	
<u>Concrete Piles</u>	Condition Rating (circle one): NI 1 2 3 4 5 <div style="text-align: right; margin-top: -10px;">(See p. 25 of Appendix A)</div>
Comments:	

(continued on next page)

INSPECTION FORM
(continued from previous page)

Comments:	<u>Other Construction Materials</u>
Comments:	<u>Ladder</u>
Comments:	<u>Platform</u>
Comments:	<u>Tower</u>
Comments:	<u>Concrete Foundation</u>
Comments:	<u>Guy Anchors and Hardware</u>
Comments:	<u>Other Components Not Listed Above</u>

INSPECTION CHECKSHEET

Use this checksheet to generate comments for the Inspection Form

TIMBER PILES

- Check the tops of piles for physical damage, dry rot, and termite or pest infestation. Determine the depth of deterioration.
- Check for cracked, rotted, loose, or worn piles or connecting braces.
- Check pile and mast alignment. If the aid is a multi-pile structure, are the piles angled toward each other evenly? Is the mast out of plumb?
- Visually examine piling in the tidal zone for marine borer damage.
- Sound the piles with a hammer and carefully probe with a thin-pointed tool such as an ice pick to look for internal decay and soft timber.
- Check for member damage due to overload or impact.
- Clear a section of the structure of all marine growth and visually inspect for surface deterioration.
- Check for corrosion of steel fasteners, including bolts, drift pins, and wire rope.

STEEL PILES

- Check for corrosion evidence: rust, scale, and holes, especially in the splash zone and at extreme low water level.
- Check the extent of steel member corrosion in the splash zone. Hammer the surface corrosion (use safety glasses) to remove corrosion byproducts and expose the steel below.
- Check for deformation, distortion, or deflection.
- Check for abrasion of steel structures as indicated by a worn, smooth, or polished appearance.
- Inspect welds for signs of corrosion, cracking, or breakage.
- Inspect coating for any peeling, blistering, etc.
- Check for loss of foundation material and/or scour.

CONCRETE PILES

- Inspect for cracks, spalling, corrosion of reinforcing steel, and visual signs of rust staining.
- Check for evidence of chemical deterioration, abrasion wear, and overload damage.
- Sound the piling with a hammer to detect any loose layers of concrete or delaminations.

OTHER CONSTRUCTION MATERIALS

Masonry:

- Check for missing or displaced blocks.
- Check for wall movement.

Aluminum:

- Check for corrosion.
- Check for abrasion and wear.
- Check for cracked welds.

Fiberglass:

- Check for broken members.
- Check for loose connections.
- Check for damage to the surface finish.

Plastics:

- Check for broken or damaged members.
- Check for cracking.
- Check for loose bolted connections.

Rubber:

- Check for rubber deterioration--hardening, cracking, swelling, softening.

(continued on next page)

INSPECTION CHECKSHEET

(continued from previous page)

LADDER

- Check horizontal and vertical alignment. Is the ladder misaligned?
- Does the ladder vibrate or move from the current or waves, or when the boat berths against it?
- Are there signs of damage caused by vessel impact, ice, logs, or other debris?
- Check ladders for corroded, broken, bent, or missing rungs.
- Check for corroded, loose, or failed connections.
- Inspect welds for signs of corrosion, cracking, or breakage.
- Inspect the ladder safety device to ensure the safety rail is properly mounted on the tower. The rail sections should be installed right-side up (notches are at the bottom of the tapered cuts vice the top). Look for worn, broken, or defective notches.
- Check the ladder safety device to ensure the sliders ride freely on the rail.
- Inspect the clamps, studs, bolts, and nuts which secure the safety device to the ladder for corrosion, looseness, and breakage.
- Ensure the top of the safety rail is capped with a through bolt or other device to prevent the removal of the slider from the top of the rail.
- Ensure the safety rails are not painted, as this will cause problems with the passage of sliders.

PLATFORM

- Inspect the platform decking or grating for structural integrity and soundness.
- Check the railings for deterioration and parts that are broken, severely bent, or otherwise considered unsafe.

TOWER

- Inspect structural members and connections for corrosion, deformation, fatigue, and differential movement.
- Look for corrosion at the bolts and joints that are bolted together, and for missing, loose, or damaged bolts.
- Check the plumb (straightness) of the tower.
- Check drain holes on hollow rod towers to make sure they are not obstructed. The amount of rust leaking out can be an indication of the extent of the rust damage inside the hollow member.

CONCRETE FOUNDATION

- Inspect the concrete foundation above grade for signs of cracking or spalling. If conditions of the above grade concrete are poor, an area adjacent to the foundation should be excavated to check the condition of the concrete below grade.
- Inspect the soil surrounding the tower foundation for evidence of settlement or upheaval.
- Inspect the anchor bolts connecting the concrete foundation to the steel tower for deformation, loose nuts, corrosion, or defects.

GUY ANCHORS AND HARDWARE

- Inspect guy anchors, turnbuckles, thimbles, shackles, preformed dead end guy grips, shear pins, and cotter pins for signs of corrosion, deformation, and fatigue.
- Check preformed guy grips to ensure there is no change in surface appearance of the guy strand immediately next to these grips.
- Ensure turnbuckles are properly moused with safety wire to prevent loosening of the turnbuckles. Also, turnbuckle threads should be coated with a light coat of petroleum based grease to prevent their binding.
- Inspect structural guys for signs of bird caging, corrosion, fatigue, deformation, and broken strands. In weather conditions where there is no wind, a slack guy wire can be an indication that something is wrong.
- Make sure that all safeties are installed and check the anchor where it enters the ground for corrosion.



AIDS TO NAVIGATION MANUAL - STRUCTURES

APPENDIX B

DATA SHEETS

**COMDTINST M16500.25
AUGUST 2003**

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DATA SHEET 1 - SINGLE PILE WOOD



Description. A single pile wood structure is commonly used for lighted and unlighted aids in marine locations where exposure and bottom conditions permit. Typical use would be in protected and semi-exposed environments. Advantages include low cost, ready availability, and ease of construction. Disadvantages include susceptibility to marine borers, rotting, ice damage, beetle attack, and brooming of the tip during driving. When subject to a moderate collision, a wood pile will snap upon failure.

Physical Characteristics.

- Wood: Douglas Fir or Southern Pine, conforming to ASTM Standard D25.
- Preservative Treatment: Chromated Copper Arsenate (CCA) or Acid Copper Chromate (ACC), conforming to AWWA Standard P-5 and C-3. No preservative treatment is required if knockdown is expected within 12 months or less.
- Common pile lengths: 45' and 60'.
- Maximum water depth: 20'.

Structural Requirements. Two requirements must be met to achieve the full structural capability of a single pile wood structure:

- The pile must achieve fixity.
- The physical integrity of the pile must be maintained (i.e., it must be free from brooming, splitting, etc.).

Related Equipment. For lighted aids, a prefabricated platform is required to support dayboards, power systems, light signals, and servicing personnel. For unlighted aids, dayboards can be affixed directly to the pile without the use of a platform.

ATONIS Abbreviation. SPW (Single Pile Wood)

DATA SHEET 1 - SINGLE PILE WOOD (continued)

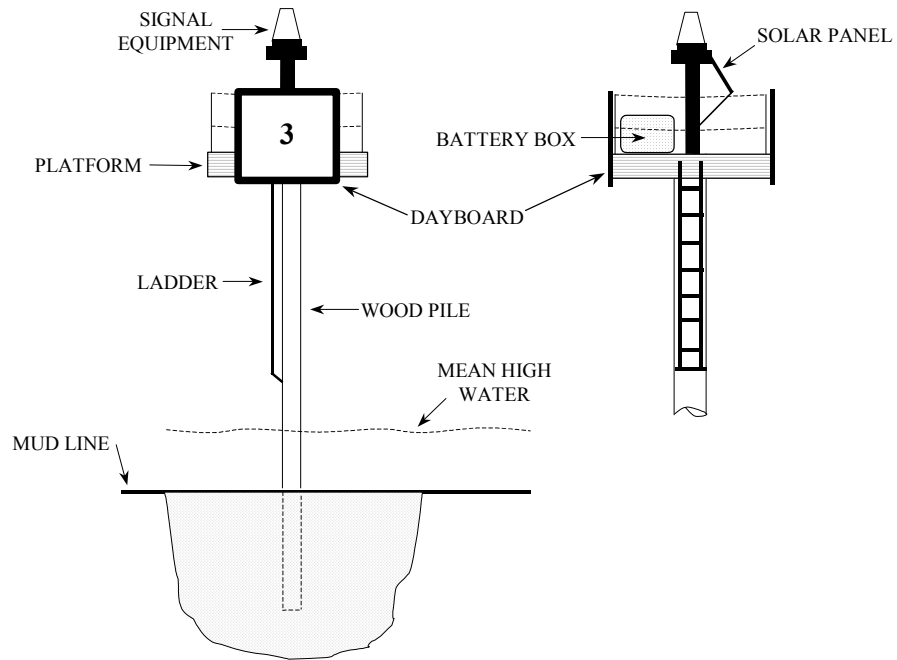


Figure 1-1 - Single Pile Wood Structure (Lighted)

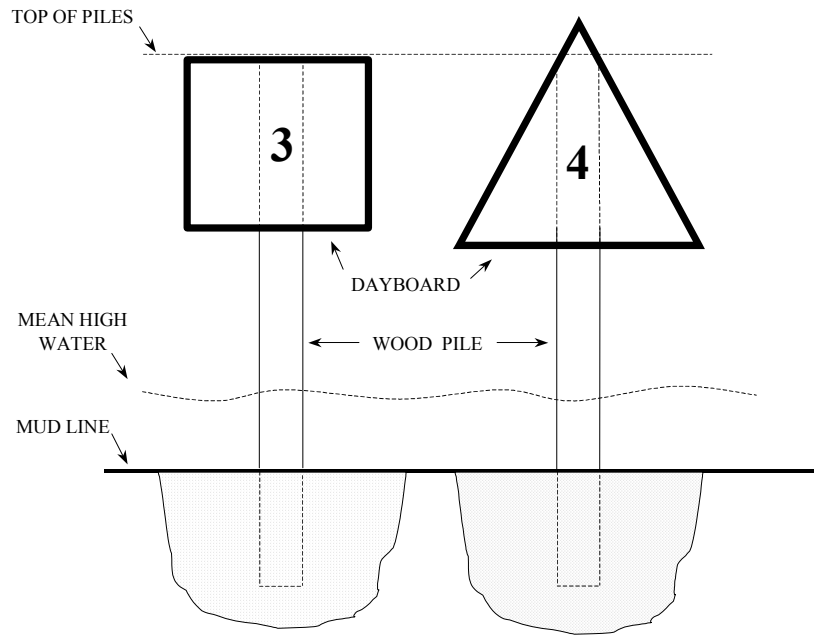


Figure 1-2 - Single Pile Wood Structure (Unlighted)

DATA SHEET 2 - SINGLE PILE STEEL



Description. A single pile steel structure is commonly used for lighted and unlighted aids in marine locations where exposure and bottom conditions permit. This is generally the most effective type of pile for moderate ice conditions or hard bottom areas. Advantages include the relative permanence of the aid, the ability to withstand hard driving and moderate collisions, and the ability to achieve long lengths by welding sections together. Disadvantages include higher cost and limited availability as compared with wood. When subject to moderate collisions, a steel pile will yield and can be straightened to its original position.

Physical Characteristics.

- Steel: 12" or 18" diameter steel pipe, or 12H53 "H" piling.
- Preservative Treatment: Tarsol or corrosion-resistant steel.
- Common lengths: 30', 40', 50' and 60'.
- Maximum water depth: 20'.

Related Equipment. For lighted aids, a prefabricated metal platform is required to support dayboards, power systems, light signals, and servicing personnel. For unlighted aids, dayboards can be affixed directly to the pile without the use of a platform.

ATONIS Abbreviation. SPS (Single Pile Steel)

DATA SHEET 2 - SINGLE PILE STEEL (continued)

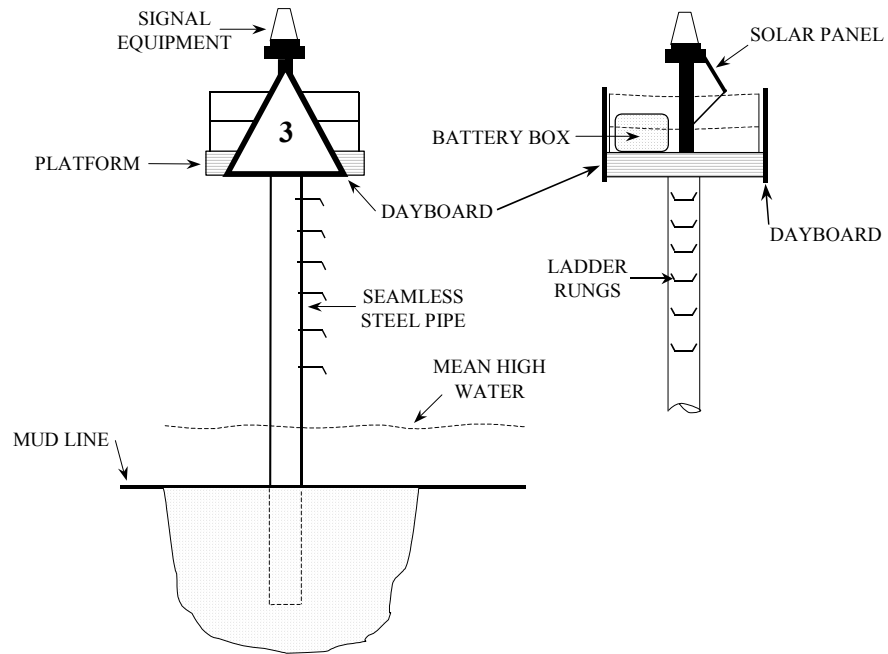


Figure 2-1 - Single Pile Steel Structure (Lighted)

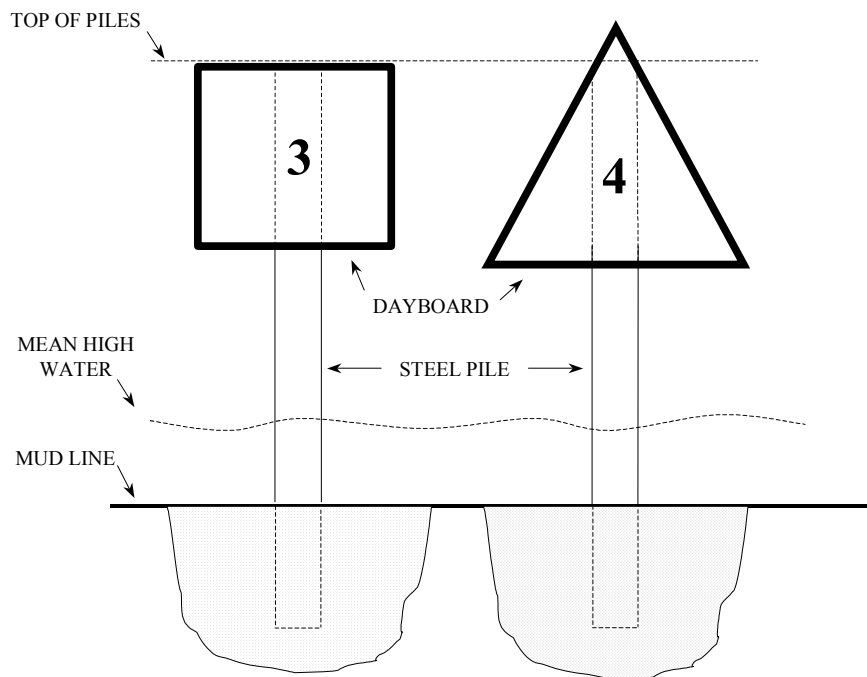


Figure 2-2 - Single Pile Steel Structure (Unlighted)

DATA SHEET 3 - SINGLE PILE CONCRETE



Description. A single pile concrete structure is used for lighted and unlighted aids in marine locations where exposure and bottom conditions permit. Typically, these are used as a last resort when wood or steel piles are not readily available. Advantages include resistance to decay and ease of manufacture. Disadvantages include cost, weight, difficult to handle, prone to corrosion of internal steel members, possibility of cracking during pile driving. When subject to a moderate collision, a concrete pile will snap upon failure.

Physical Characteristics.

- Concrete: 10", 12", or 14" square or octagonal shapes.
- Common pile lengths: 40', 50', and 60'.
- Maximum water depth: 20'.

Structural Requirements. Two requirements must be met to achieve the full structural capability of a single pile concrete structure:

- The pile must achieve fixity.
- The physical integrity of the pile must be maintained (i.e., it must be free from cracking, spalling, etc.).

Related Equipment. For lighted aids, a prefabricated metal or concrete slab platform is required to support dayboards, power systems, light signals, and servicing personnel. For unlighted aids, dayboards can be affixed directly to the pile without the use of a platform.

ATONIS Abbreviation. SPC (Single Pile Concrete)

DATA SHEET 3 - SINGLE PILE CONCRETE (continued)

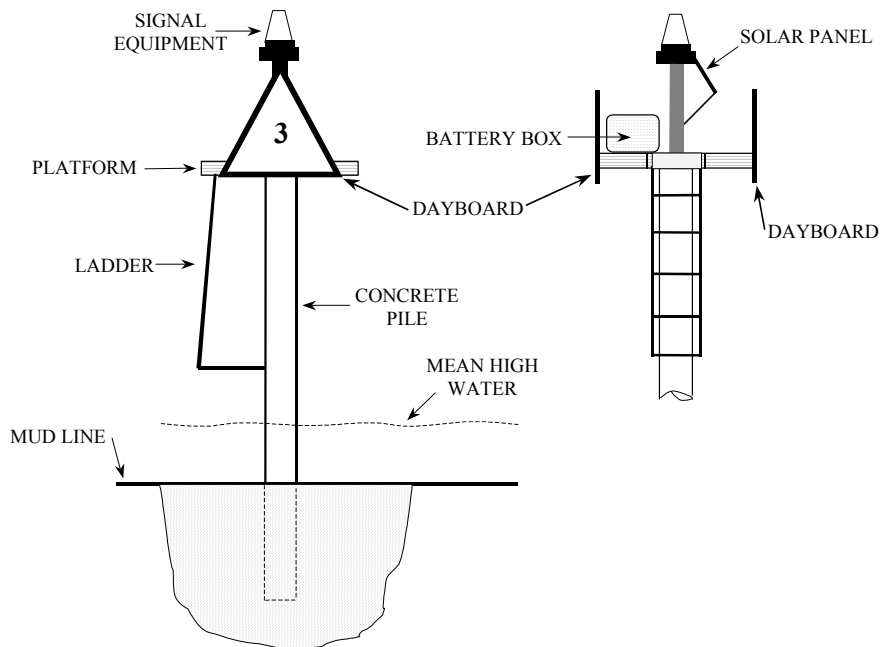


Figure 3-1 - Single Pile Concrete Structure (Lighted)

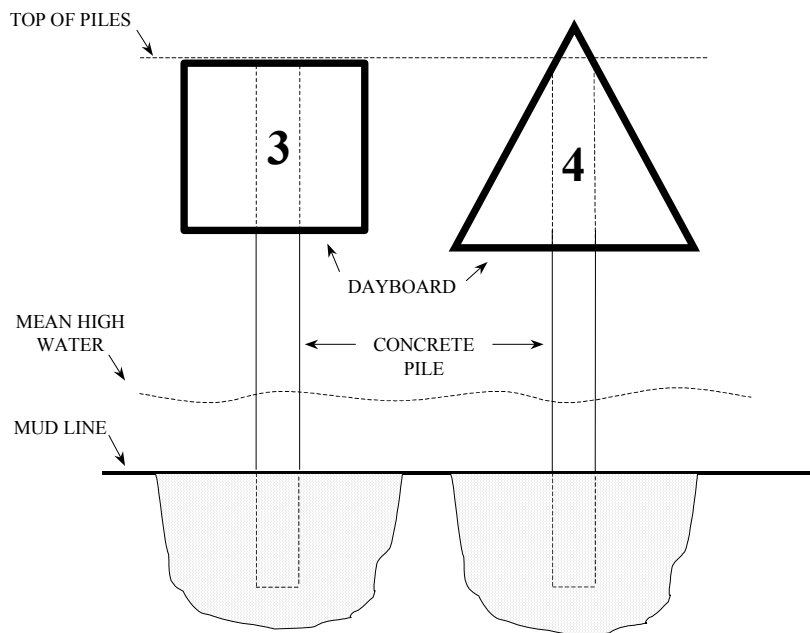


Figure 3-2 - Single Pile Concrete Structure (Unlighted)

DATA SHEET 4 - POST



Description. A post (steel, aluminum, or concrete) is used for lighted and unlighted aids on land sites. It is usually secured to a concrete foundation.

Structural Requirements. The critical element of a post structure is generally the overturning moment developed at the connection between the foundation and the post. The structure must be designed to resist this overturning moment caused by environmental forces.

Related Equipment. For lighted aids, a prefabricated platform can be used to support dayboards, power systems, light signals, and servicing personnel. Since the structure is land based, commercial power can also be supplied with wiring run through an opening at the base of the post, up to the light signal. For unlighted aids, dayboards can be affixed directly to the structure without the use of a platform.

ATONIS Abbreviation. POST (not currently used in ATONIS)

DATA SHEET 4 - POST (continued)

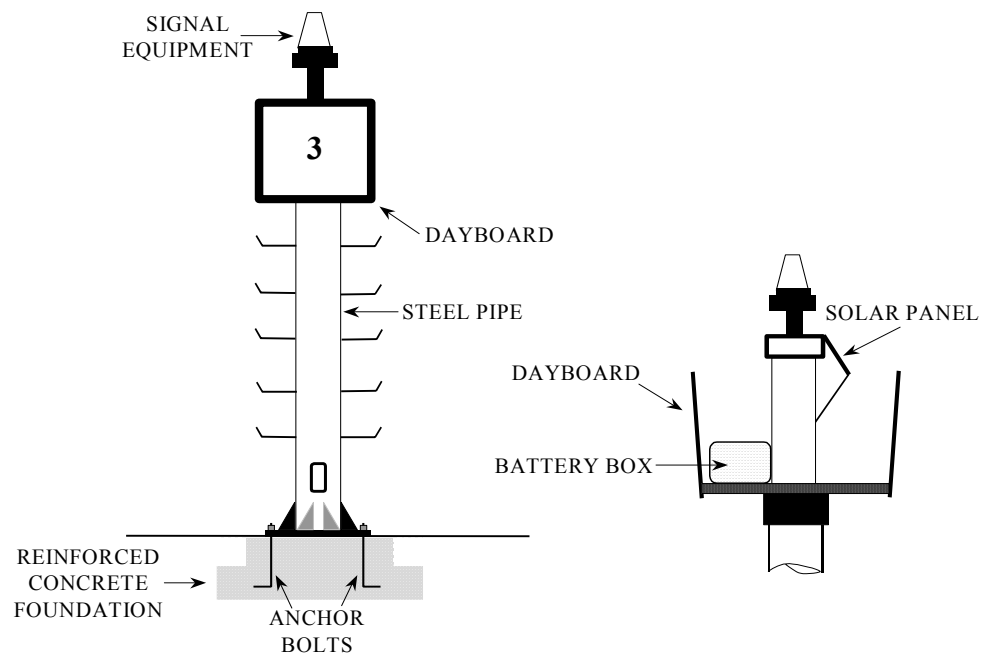


Figure 4-1 - Post Structure

DATA SHEET 5 - SPINDLE



Description. A spindle is a specialized structure used for lighted and unlighted aids in tidal areas and on land sites. It consists of single pole made of various lengths of pipe connected end-to-end, and is usually secured to a concrete foundation or to steel stakes embedded into rock with grout.

Structural Requirements. The critical elements of a spindle are the flanges connecting the various sections and the connection between the pipe and the foundation. The structure must be designed to resist overturning moments caused by environmental forces.

Related Equipment. For lighted aids, a prefabricated platform can be used to support dayboards, power systems, light signals, and servicing personnel. Since the structure is land based, commercial power can also be supplied with wiring run through an opening at the base of the post, up to the light signal. For unlighted aids, dayboards can be affixed directly to the structure without the use of a platform.

ATONIS Abbreviation. SPINDLE

DATA SHEET 5 - SPINDLE (continued)

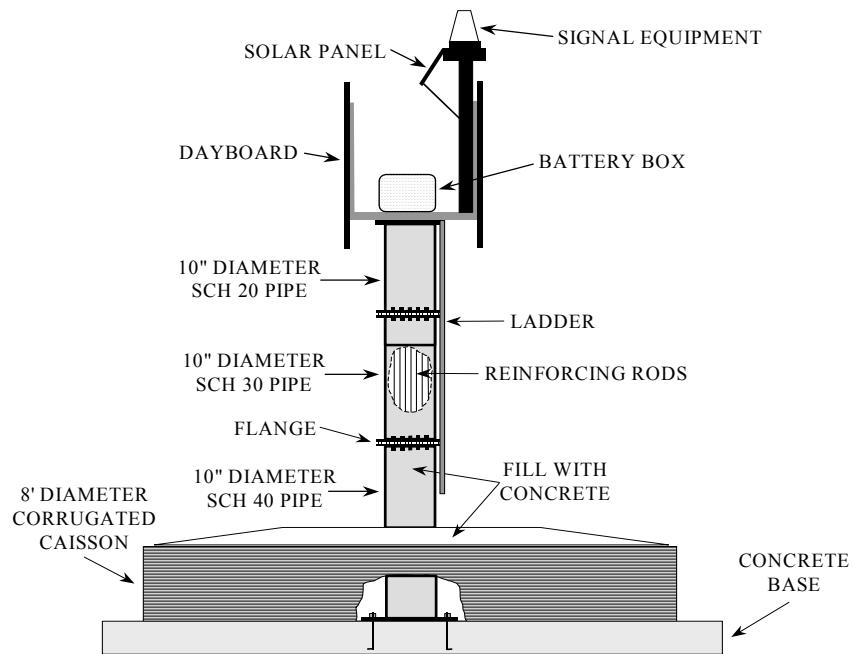


Figure 5-1 - Spindle Structure with Flange Connections

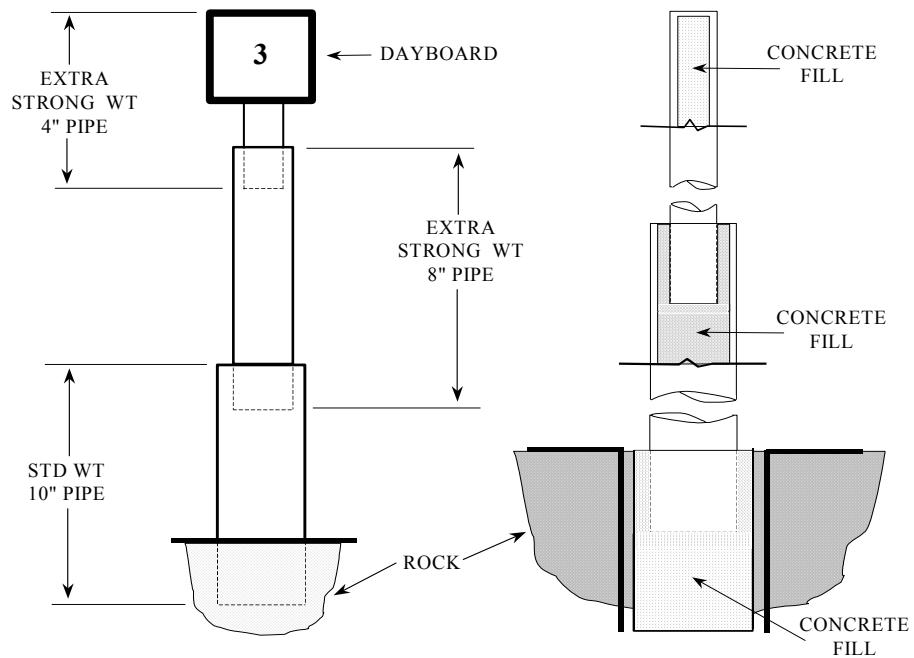


Figure 5-2 - Spindle Structure with Gravity Connections

DATA SHEET 6 - BATTERED PILE DOLPHIN



Description. A battered pile dolphin structure is used on marine sites for lighted or unlighted aids when a single pile structure is not effective because of soft bottom or exposure conditions such as severe wind or wave action. The basic configuration involves three or more piles (wood, steel, or concrete) driven on an angle to the vertical with the tops connected by "thru bolts" or wrapped with cable.

Related Equipment. For lighted aids, a prefabricated platform can be used to support dayboards, power systems, light signals, and servicing personnel. For unlighted aids, dayboards can be affixed directly to the structure without the use of a platform.

ATONIS Abbreviation. MPW# (Multiple Pile Wood), MPS# (Multiple Pile Steel), MPC# (Multiple Pile Concrete), where "#" indicates the number of piles used in construction.

DATA SHEET 6 - BATTERED PILE DOLPHIN (continued)

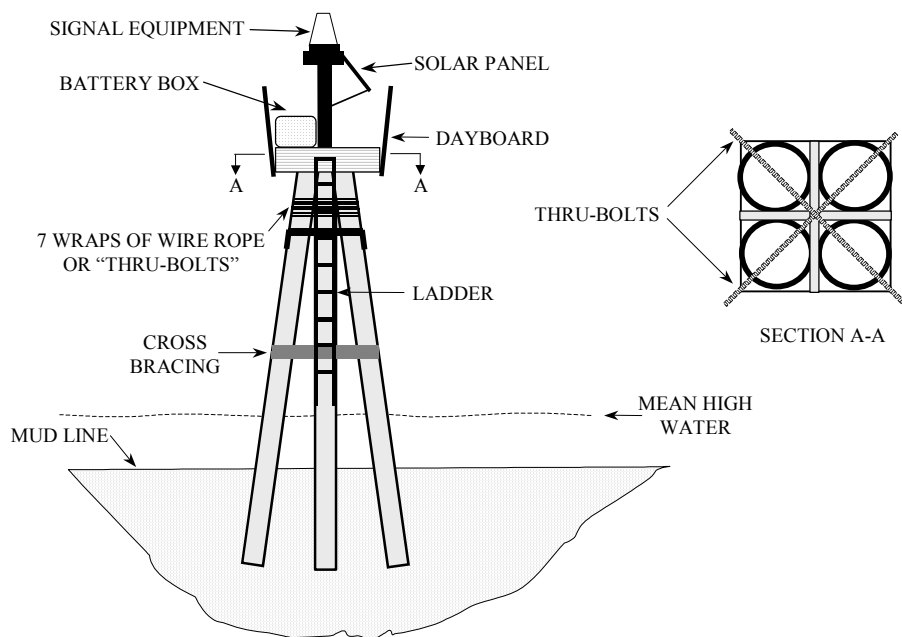


Figure 6-1 - Battered Pile Wood Structure

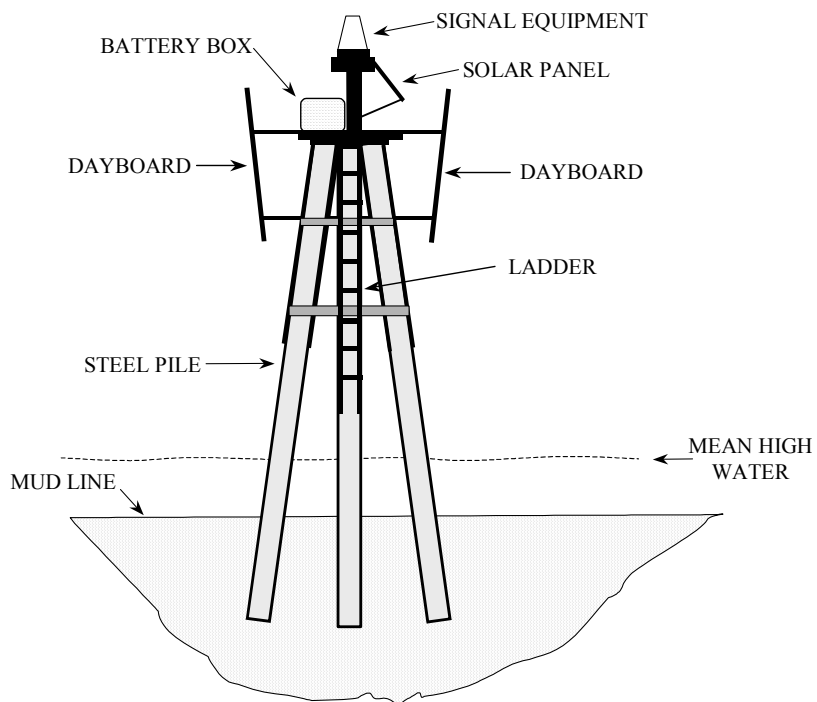


Figure 6-2 - Battered Pile Steel Structure

DATA SHEET 7 - CLUSTER PILE DOLPHIN



Description. A cluster pile dolphin structure is used on marine sites for lighted or unlighted aids when a single pile structure is not effective because of exposure conditions such as severe wind or wave action. The basic configuration involves three or more piles (usually wood) driven vertically, skin-to-skin, and wrapped tightly together at various heights.

Related Equipment. For lighted aids, a prefabricated platform can be used to support dayboards, power systems, light signals, and servicing personnel. For unlighted aids, dayboards can be affixed directly to the structure without the use of a platform.

ATONIS Abbreviation. SISTERPILE

DATA SHEET 7 - CLUSTER PILE DOLPHIN (continued)

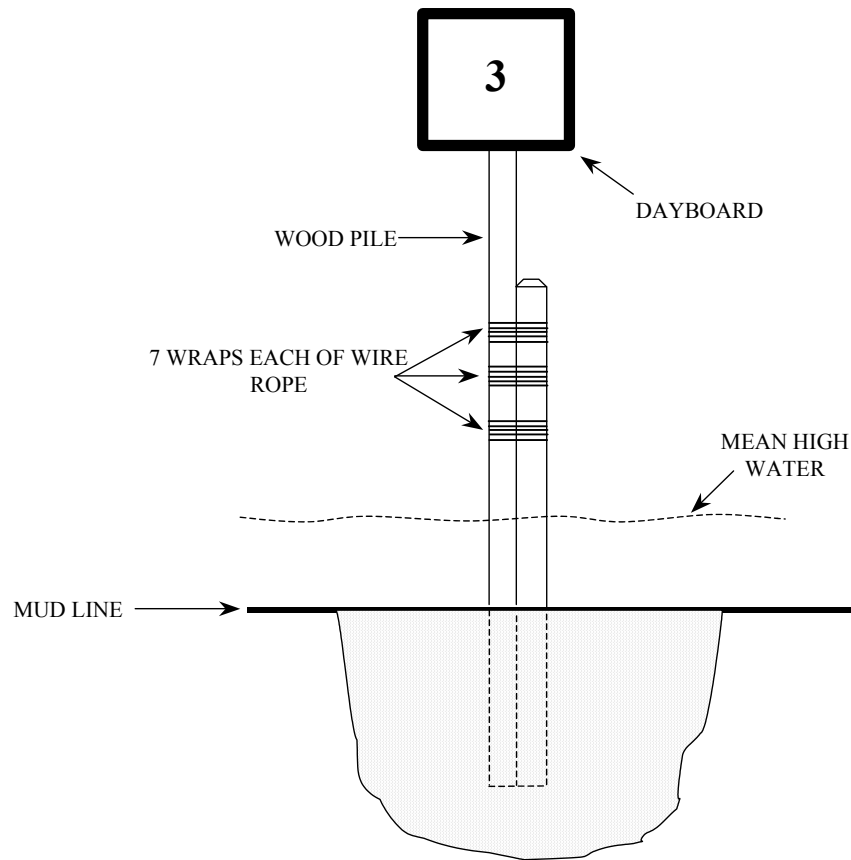


Figure 7-1 - Cluster Pile Dolphin Structure

DATA SHEET 8 - MULTIPLE PILE PLATFORM



Description. A multiple pile platform structure is used on marine sites normally as a foundation for a skeleton tower when the focal height of the aid is over 30 ft, as with a range structure.

Related Equipment. A prefabricated metal or wood platform is required to support up to a 50-ft skeleton tower with dayboards, power systems, light signals, and servicing personnel as necessary.

ATONIS Abbreviation. Because this aid often combines a multiple pile platform with a skeleton tower, there is currently no single ATONIS abbreviation that is used consistently for this structure type.

DATA SHEET 8 - MULTIPLE PILE PLATFORM (continued)

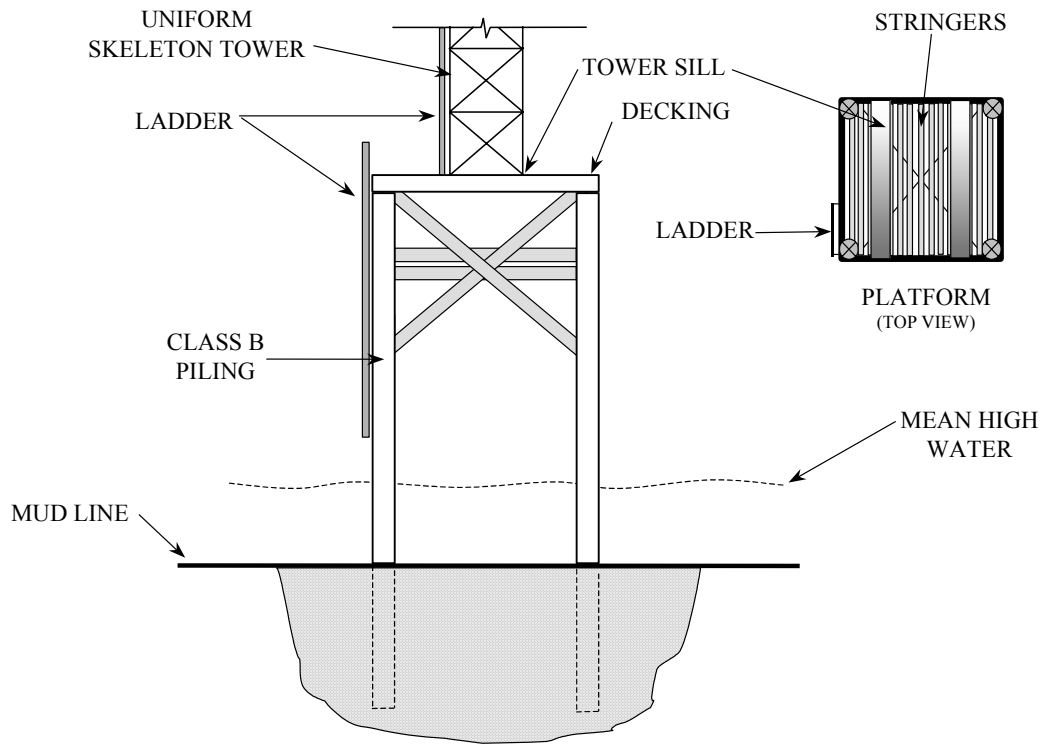


Figure 8-1 - Multiple Pile Platform Structure (Wood)

DATA SHEET 8 - MULTIPLE PILE PLATFORM (continued)

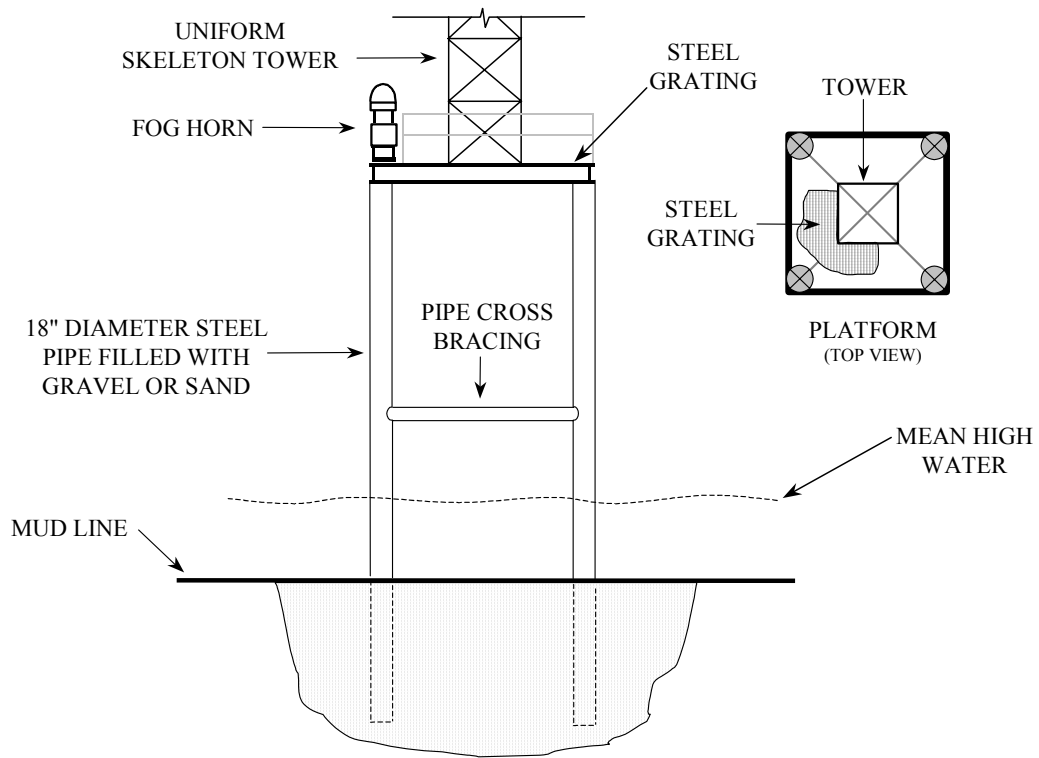


Figure 8-2 - Multiple Pile Platform Structure (Steel)

DATA SHEET 9 - FREE-STANDING SKELETON TOWER



Description. A free-standing skeleton tower is an efficient and economical means of supporting signal equipment on land or marine sites where it is not feasible to guy the structure. This type of tower is especially effective when the focal height needed for the operational requirements of the beacon is over 30 ft, as with range structures.

Related Equipment. A prefabricated platform can be used to support dayboards, power systems, light signals, and servicing personnel as necessary. Dayboards can be affixed directly to the structure without the use of a platform.

ATONIS Abbreviation. STL SKELTOW or WxD TOWER, where "w" is width and "d" is depth in feet.

DATA SHEET 9 - FREE-STANDING SKELETON TOWER (continued)

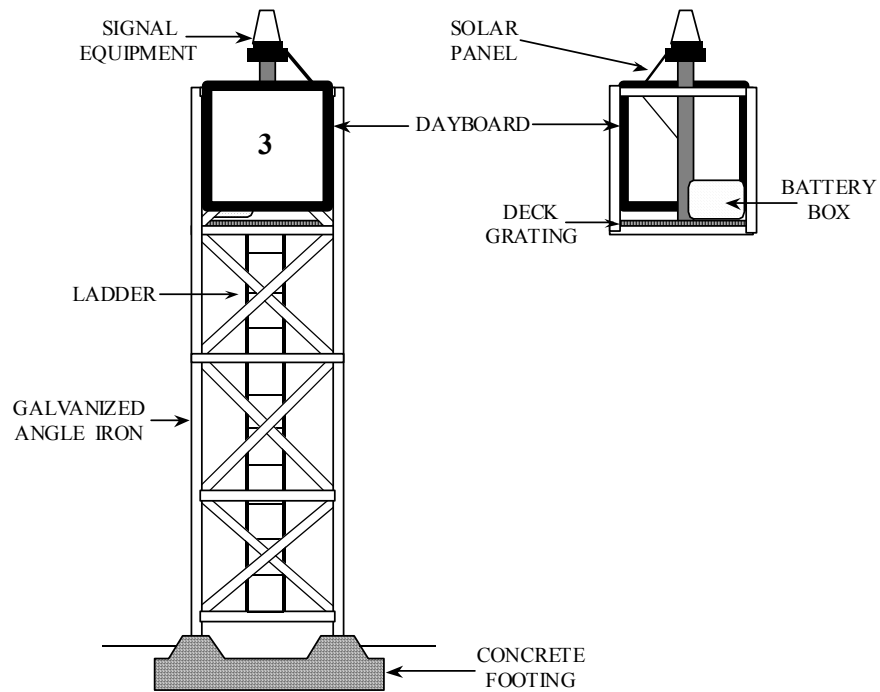


Figure 9-1 - Freestanding Angle Iron Skeleton with Concrete Footings on Land

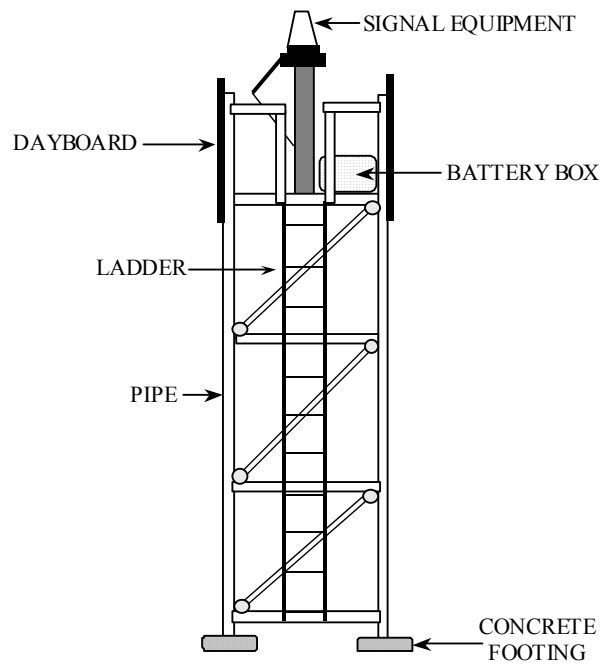


Figure 9-2 - Freestanding Pipe Skeleton with Concrete Footings on Land

DATA SHEET 10 - GUYED SKELETON TOWER



Description. Where feasible, a guyed skeleton tower is an efficient and economical means to support signal equipment on land.

Related Equipment. A prefabricated platform can be used to support dayboards, power systems, light signals, and servicing personnel as necessary. Since the structure is land based, power systems can be maintained at the base of the structure. Dayboards can be affixed directly to the structure without the use of a platform.

ATONIS Abbreviation. ## ROHNTWR, where '##' indicates the structure height in feet.

DATA SHEET 10 - GUYED SKELETON TOWER (continued)

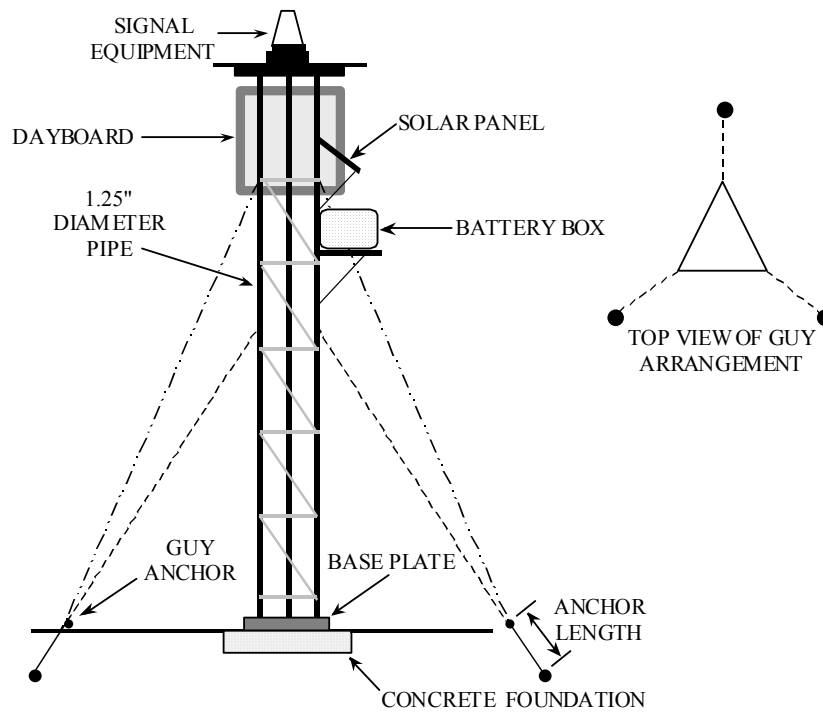
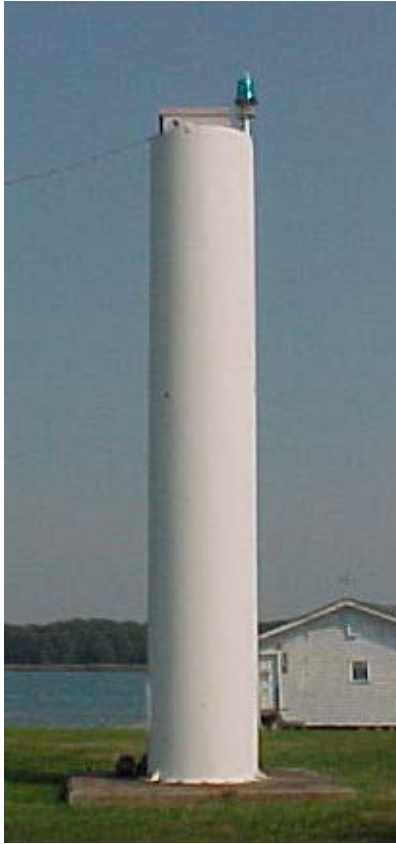


Figure 10-1 - Single Guyed Skeleton Tower

DATA SHEET 11 - D9 CYLINDER TOWER



Description. A cylinder structure typically consists of a 5' diameter by 20' tall steel cylinder on a concrete foundation. A variation of this structure is similar, but 9' diameter and 30' tall. The structure has a watertight door, interior ladder, storage shelves, and a skylight hatch on top for access to the signal equipment. Advantages of this structure include being an excellent daymark, vandal resistance, and providing weather protection to servicing personnel.

Physical Characteristics.

- Steel: 5' x 20' (or 9' x 30') cylindrical structure
- White epoxy paint system w/ colored band (if lateral significance is required)
- Concrete foundation

Related Equipment. Typically a lighted aid, requiring a power system and light signal.

ATONIS Abbreviation. CYLINDRICAL

DATA SHEET 11 - D9 CYLINDER TOWER (continued)

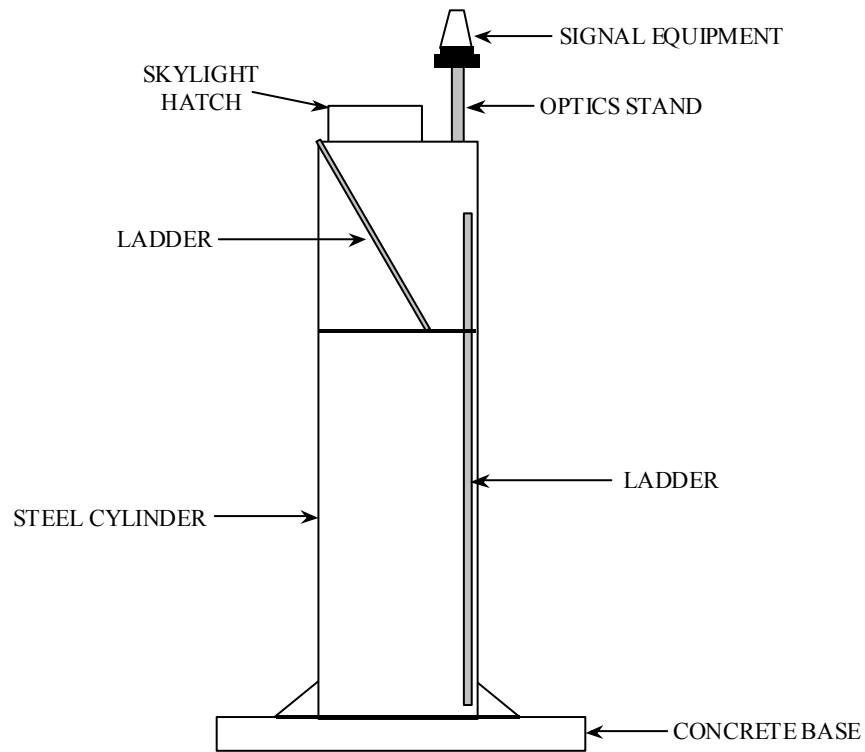


Figure 11-1 - D9 Cylinder Tower

DATA SHEET 12 - JAMES RIVER ICE RESISTANT STRUCTURE (JRIRS)



Description. A JRIRS consists of a four-pile steel dolphin and an 8' or 10' square platform. It typically serves as a foundation for a steel skeleton tower. They are often fabricated by Coast Guard industrial facilities and installed by construction tenders (WLICs). An 18" diameter "king pile" is driven on the surveyed position, a template is placed over this pile, and three 12" diameter batter piles are driven through the template. The platform is then mounted on the dolphin foundation. The design height for the platform is 11-15 feet above MHW. The JRIRS makes a good offshore, shallow-water structure capable of withstanding light to moderate icing conditions.

Related Equipment. The platform, mounted on the dolphin foundation, supports a tower of required height. The tower can be used to support dayboards, power systems, light signals, and servicing personnel as necessary.

ATONIS Abbreviation. JRIRS

DATA SHEET 12 - JAMES RIVER ICE RESISTANT STRUCTURE (continued)

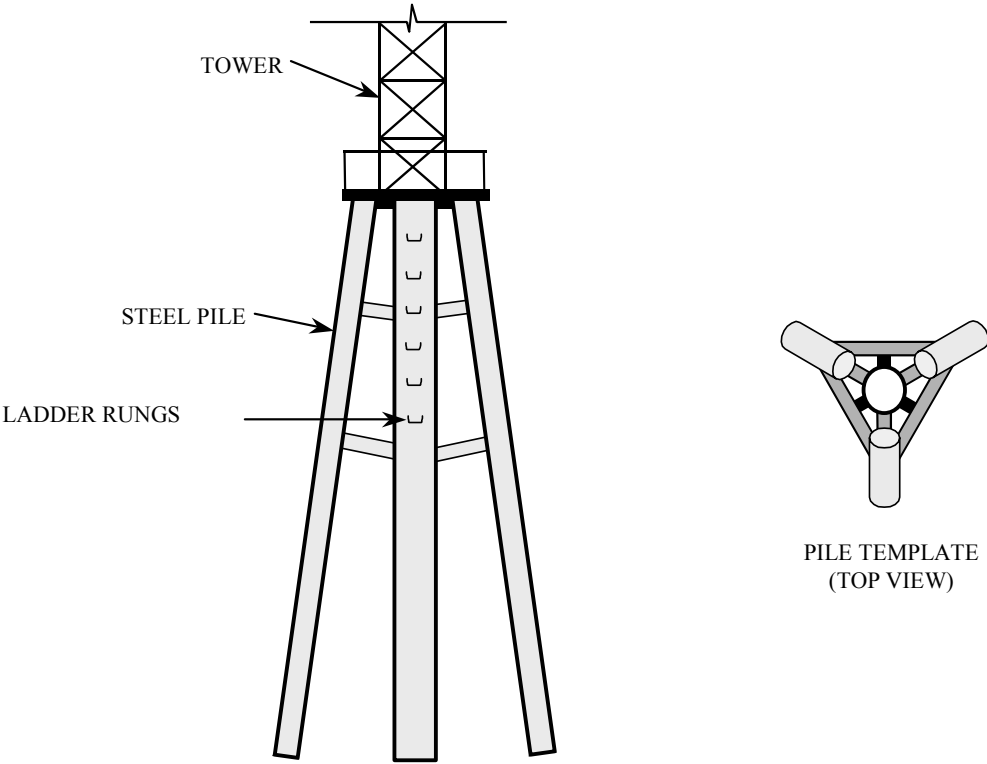


Figure 12-1 - James River Ice Resistant Structure

DATA SHEET 13 - CAISSON FOUNDATION

Function. A caisson is a steel or reinforced concrete cylinder normally used to support a skeleton tower. It is used when site conditions are severe, as with a heavy ice flow, or when the foundation is in an exposed area and a more permanent structure is needed. The cylinder serves as a form to hold rock, sand, or concrete.

Structural Requirements. A caisson foundation shall be designed to be compatible with the design loads of the superstructure and to withstand the environmental loading of semi exposed or exposed site locations.

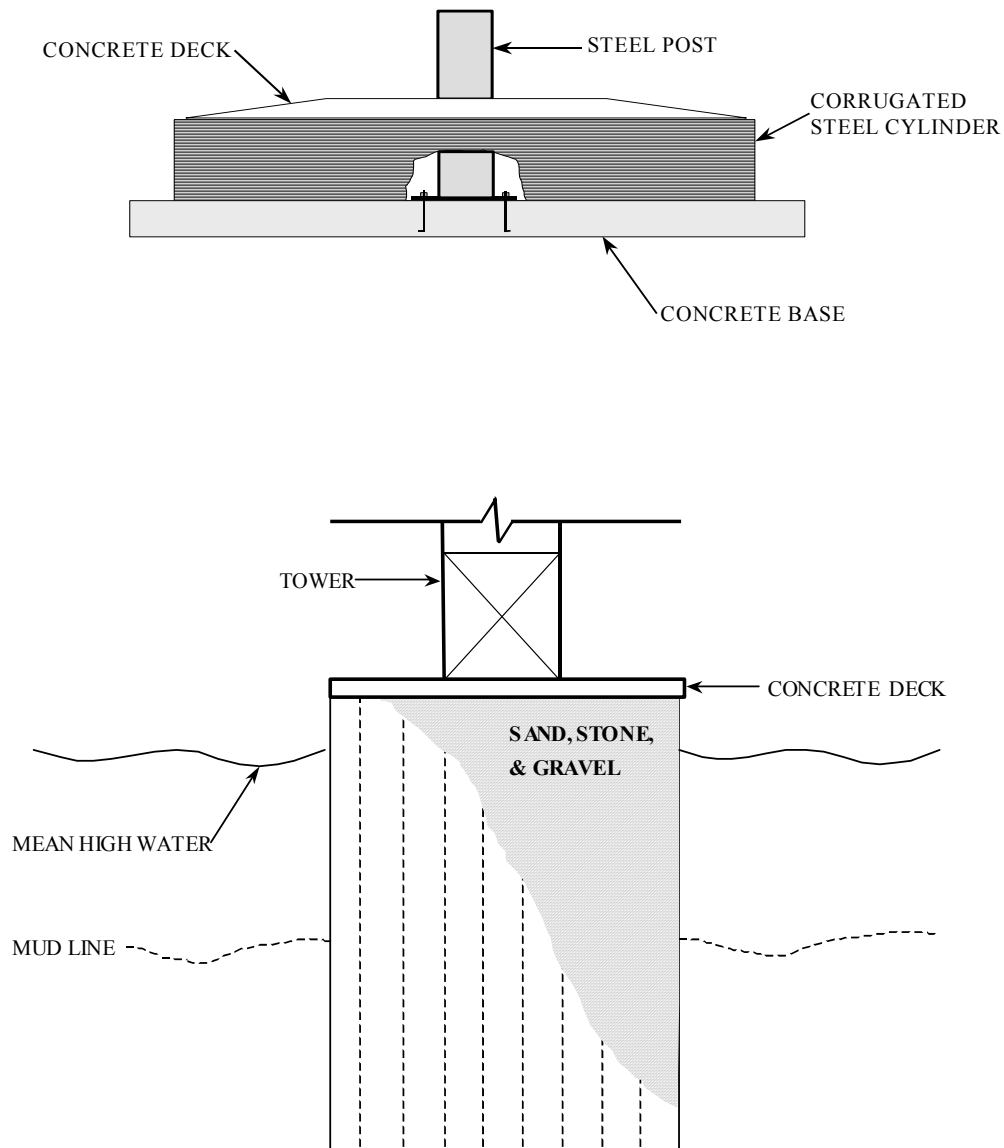


Figure 13-1 - Caisson Foundation

DATA SHEET 14 - MUD SILL FOUNDATION

Function. A mud sill foundation is used to support beacon structures in locations where the underlying stratum is unstable, such as in a swampy area. This foundation is basically a specialized platform structure.

Physical Characteristics.

- Primary structural components: 10" X 12" timbers.
- Preservative treatment: Chromated Copper Arsenate (CCA) or Acid Copper Chromate (ACC), conforming to AWWA Standard P-5 and C-3.
- Horizontal configuration: 12' X 12' through 18' X 18'.

Structural Requirements. A mud sill foundation is designed to distribute the structural load over a greater area than normal by increasing the lateral dimension when the height of structure is increased. The timbers absorb the bearing load, the shear forces are taken by the corner pilings, and the overturning moment is resisted by the width of the foundation. For special isolated cases, guy wires can be used to further resist the overturning moments.

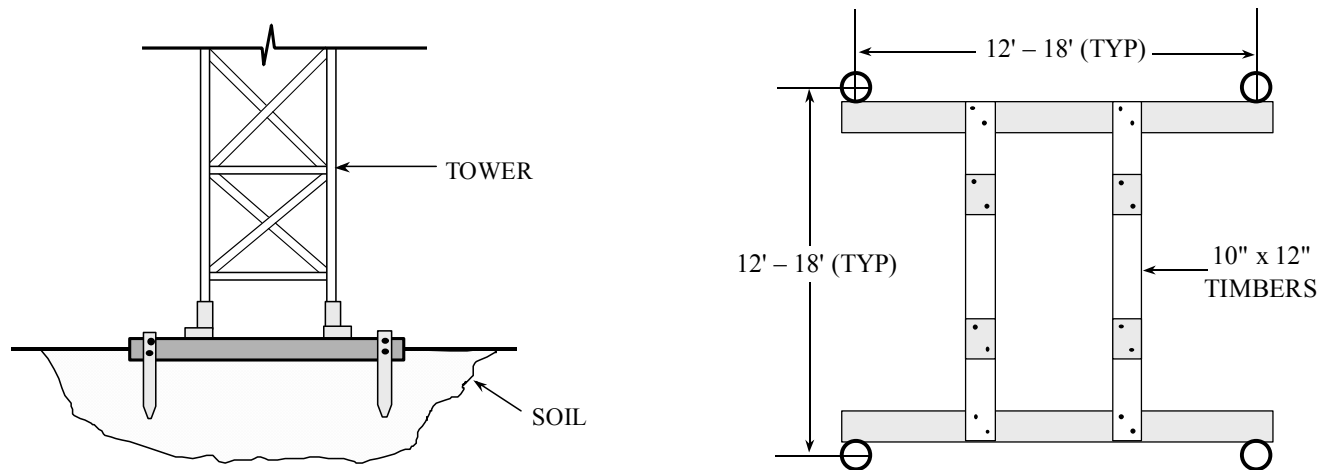


Figure 14-1 - Mud Sill Foundation

DATA SHEET 15 - CONCRETE FOUNDATION

Function. Concrete footings or concrete slab foundations are used to support structures on land.

Structural Requirements. Concrete footings and slabs shall be designed to be compatible with the design loads of the structure, the overturning moment developed by environmental forces, and the allowable bearing capacity of the soil.

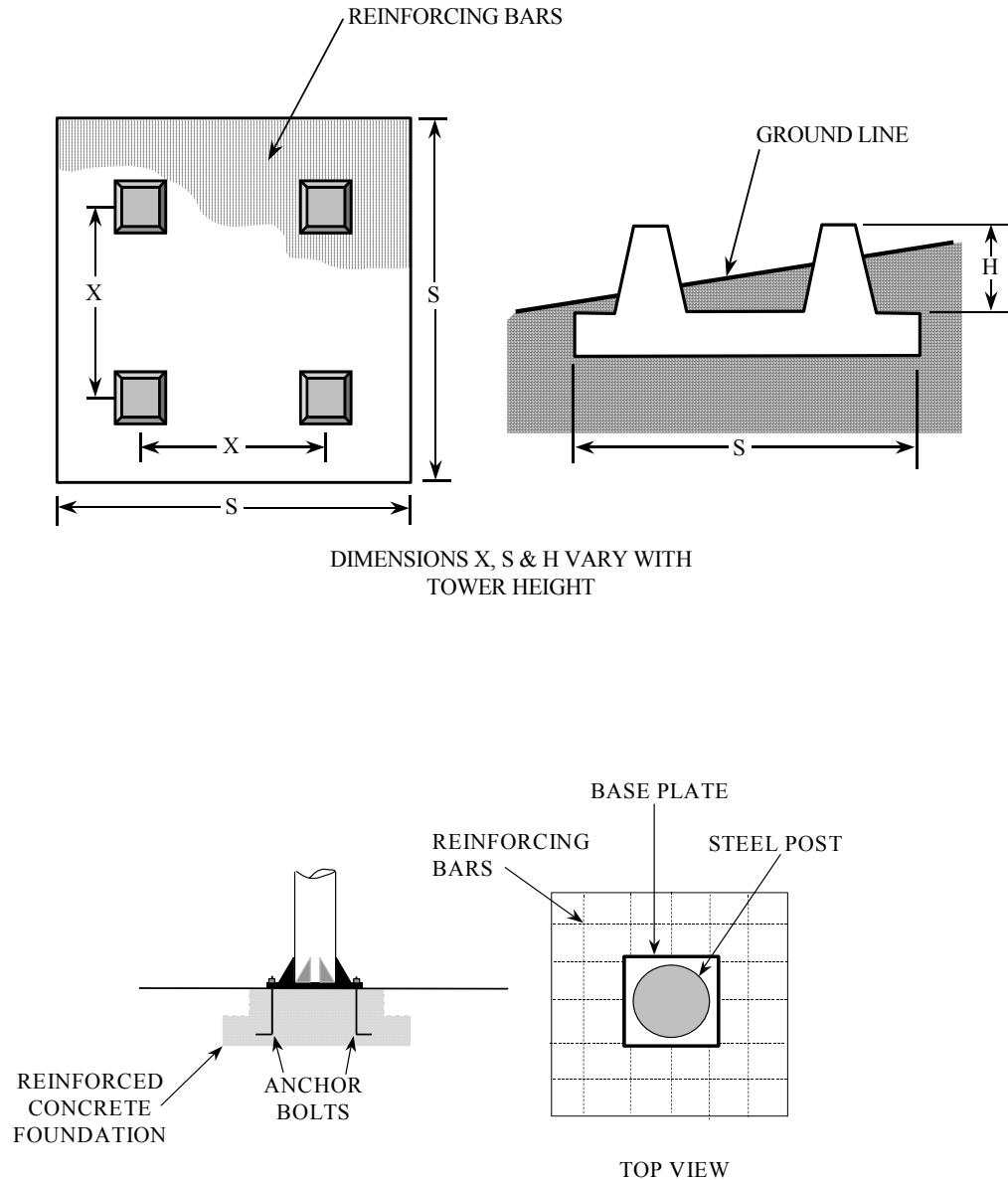


Figure 15-1 - Concrete Foundation

DATA SHEET 16 - RIPRAP FOUNDATION

Function. Riprap is a collection of relatively large-sized rocks that are placed together to protect the beacon structure and the signal equipment which it supports against ice or flooding.

Physical Characteristics.

Primary structural components: Class A rock, at least 85% consisting of rocks that weigh more than 2 tons each; class B rock, at least 60% consisting of rocks that weigh more than 100 lbs each; class C rock, rock smaller than class B, technically known as quarry waste.

Structural Requirements. Riprap shall be designed to protect against undermining and exposure of the beacon structure by properly using the weight and volume of the rock fragments to prevent washing away of the bottom.

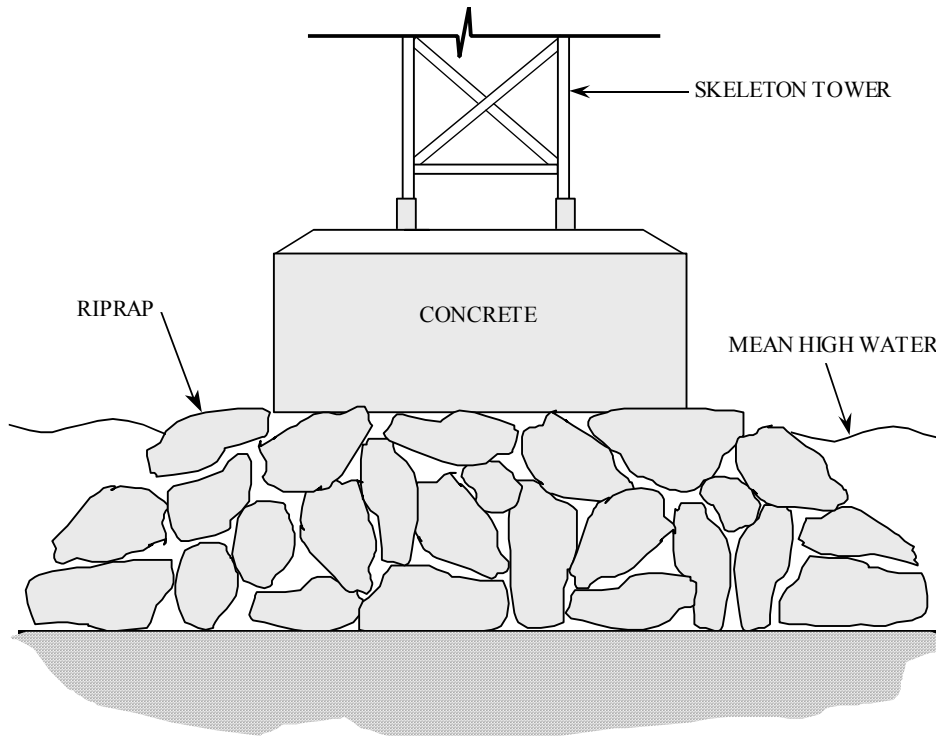


Figure 16-1 - Riprap Foundation

DATA SHEET 17 - STEEL STAKES FOUNDATION

Function. Steel stakes can be used as an effective and low-cost foundation to support skeleton towers on either a rock surface or soil. They can be used in lieu of a concrete foundation when the site location is not properly suited to concrete, such as a rock surface. Holes are drilled into the rock and anchor bolts are secured to the base plate. Rapid-setting grout is used to embed the bolts to form a firm foundation.

Structural Requirements. Steel stakes must be designed to resist the overturning moments of the structure that are developed by environmental forces.

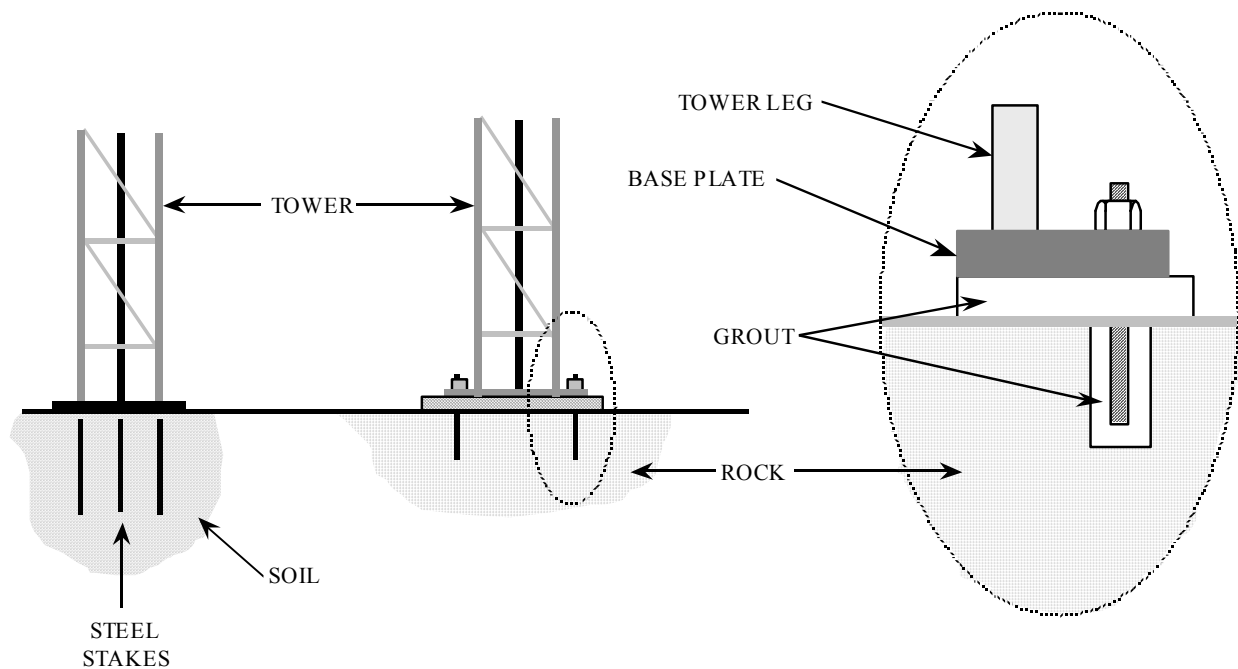


Figure 17-1 - Steel Stakes Foundation

DATA SHEET 18 - BATTERY BOX

Function. The standard Coast Guard large battery box is designed to hold up to a 1000-Ah series hookup of any of the primary batteries currently in use. A smaller model, designated the "small battery box", is designed to hold either two 12-volt or four 6-volt photovoltaic batteries. Both boxes are made of ABS plastic with a white acrylic plastic coating.

Structural Requirements. Battery boxes shall be securely fastened to the platform to withstand environmental forces.

Additional Data. The complete large battery box assembly includes a top and bottom, a stuffing tube, and a packing gland. The complete small battery box assembly contains the same items.

Available through Engineering Logistics Command Baltimore:

LARGE BATTERY BOX	(NSN 6140-01-029-6715)
SMALL BATTERY BOX	(NSN 6140-01-194-5777)
LARGE BATTERY BOX TOP	(NSN 6140-01-041-5030)
SMALL BATTERY BOX TOP	(NSN 6140-01-194-5781)

Available through National Stock System:

PLASTIC STUFFING TUBE – STRAIGHT	(NSN 5975-00-989-5046)
PLASTIC STUFFING TUBE-ANGULAR-45 DEGREE	(NSN 5975-00-989-5045)
NEOPRENE PACKING ASSEMBLY	(NSN 5330-00-202-2594)

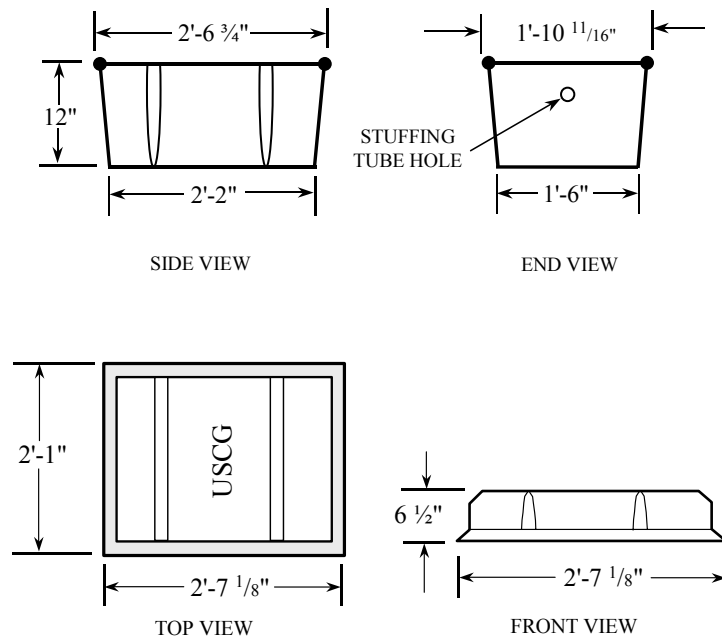


Figure 18-1 - Large Battery Box

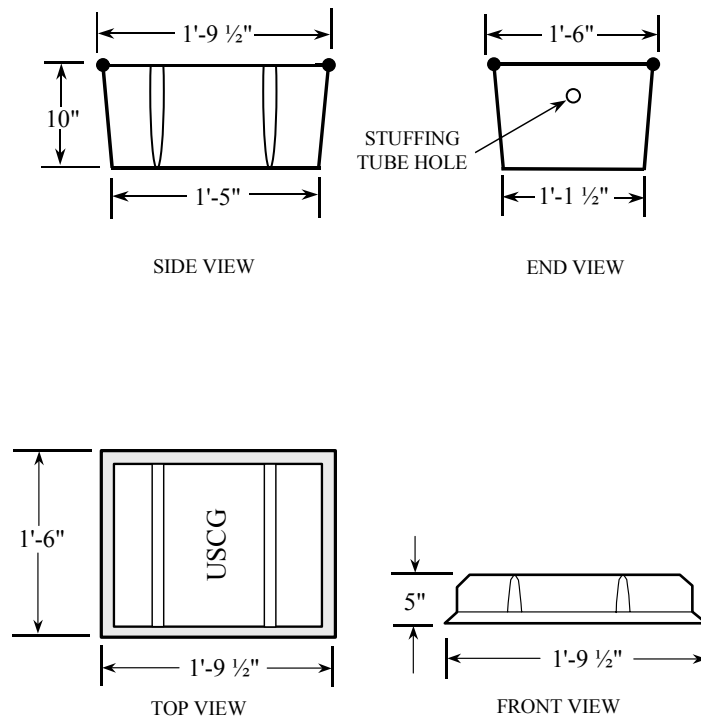


Figure 18-2 - Small Battery Box

DATA SHEET 19 - STRUCTURE RADAR REFLECTOR

Function. The structure radar reflector is designed to be installed on structures when the radar reflectivity of the structure does not meet the operational requirements.

Features.

- Galvanized steel construction.
- 1.5 to 2.0 nmi range (using two adds about 0.5 nmi).
- Weight: 8 lbs.

Additional Data. The structure radar reflector is to be manufactured or procured locally. A full-size construction drawing (Civil Engineering Drawing No. 121018) may be obtained from Commandant (G-SEC).

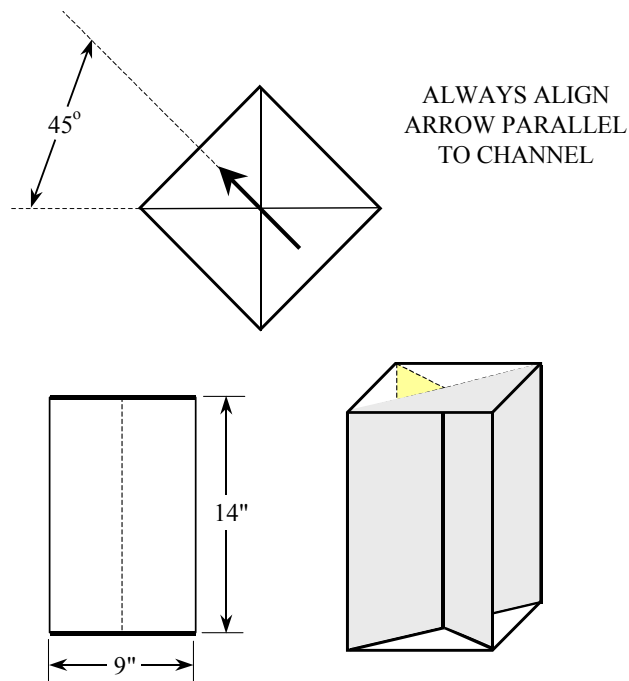


Figure 19-1 - Radar Reflector

DATA SHEET 20 FIXED AID LANTERN STAND ASSEMBLY

Function. The fixed aid lantern stand assembly provides a convenient mount for an aids to navigation lantern, solar panel, and battery box. All lanterns described in Aids to Navigation Technical Manual, COMDTINST M.16500 (series), with the exception of the DCB-24/224, can be mounted on the stand. The stand is capable of supporting one solar panel, either 10, 20, or 35 watts in size, at three tilt angles, 15, 30, and 60 degrees from horizontal. The stand is mounted to a fixed aid to navigation, with the solar panel facing south, using either carriage or lag bolts.

Additional Data. The fixed aids to navigation stand is to be manufactured or procured locally. A full sized drawing (Civil Engineering Drawing No. 120978) is available from Commandant (G-SEC).

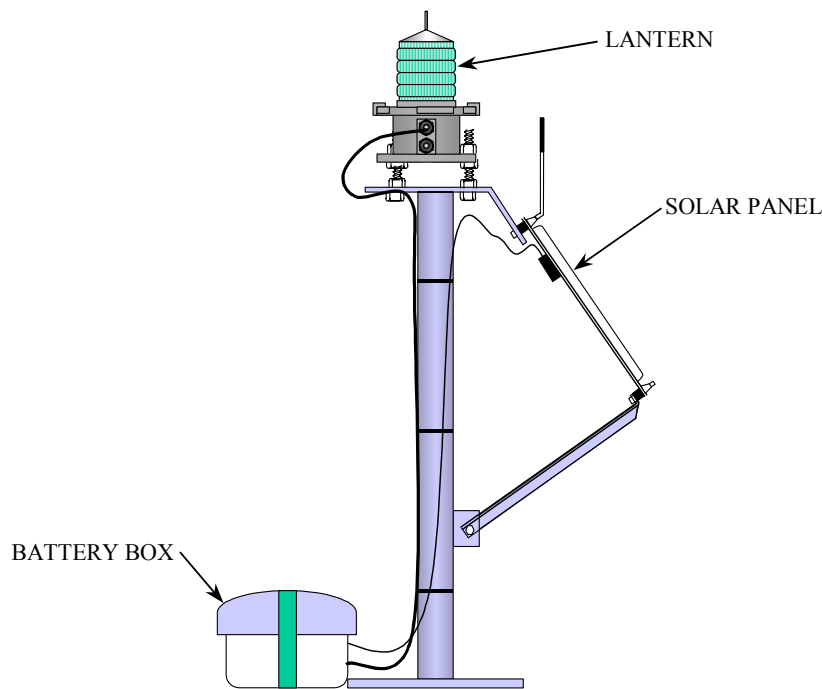


Figure 20-1 - Lantern Stand Assembly

DATA SHEET 21 - TETHERING OF ATON STRUCTURES

Function. The following measures will enhance the recovery of ATON batteries on downed structures. These measures are intended for use on single pile wood structures, but may be adapted for use on other structures types as necessary.

Background. Nearly 900 ATON structures are knocked down annually. Without utilizing the measures outlined in this Data Sheet, these knockdowns could result in lost batteries which the Coast Guard has the responsibility to retrieve. Ensuring recovery of these batteries without the costly need for divers is of paramount importance to the Coast Guard. Because the majority of single pile wood structures are in the Fifth, Seventh, and Eighth Districts, this guidance is primarily for those Districts. However, other Districts should consider installing similar preventive measures on structures in which there is a significant risk of the battery being lost.

Features. Most knockdowns are caused by collisions from passing vessels. When a vessel hits a structure, the pile usually breaks and begins to float away, the platform is separated from the pile, and/or the battery is thrown from the battery box into the water. The following measures have been developed to prevent the loss of the battery in these situations, and are intended for use with the commercially-available "Rubber Queen" type battery box:

- **Battery Bracing.** The battery box is reinforced with steel end brackets, a top bracket, and a bottom "strong-back." The top bracket and the strong-back secure the battery to the platform. The end brackets, on both ends of the box, keep the battery from being thrown from the platform.
- **Pile Tethering.** The upper portion of the pile is tethered with chain to the lower end of the pile below the mud line. This will prevent the upper portion of the pile (wreckage) from floating away from the charted position after a collision.
- **Platform Reinforcing.** The platform is reinforced with steel angles to strengthen the connection between the platform decking and the A-frame. This will help hold the platform together during a collision.
- **Platform Tethering.** The platform is tethered with chain to the upper portion of the pile. This measure will ensure that the platform remains connected to the pile and on station with the other wreckage.

Guidance for each of these measures is provided below. The materials described herein are to be manufactured or procured locally. A detailed design drawing (Civil Engineering Drawing Number 121165) is available for download on the Commandant (G-SEC-2) Internet site, at <http://www.uscg.mil/systems/gse/gse2/Drawings2B.htm>.

Battery Bracing.

The top bracket and strong-back are made from 1/8 inch thick steel. Two 4-inch galvanized or stainless steel bolts (1/2 inch diameter) are placed through the strong-back holes and welded to the strong-back during fabrication.

Installation of the battery box bracing should begin by checking the intended placement of the battery box. The battery box shall be positioned so that none of the strong-back bolts or lag bolts are on cracks in the decking.

Once placement of the box has been determined, drill two holes (10 inches center to center apart) for the strong-back bolts. Fit the bolts of the strong-back up through the drilled holes, and lag the strong-back to the bottom of the decking through the hole in the center of the strong-back. This prevents the strong-back from falling into the water when the top bracket is removed during servicing.

Place the battery in the battery box. Leave the battery box cover off. Place the top bracket over the battery and outside of the box. The top bracket should be placed across the center of the battery between the terminals, but not touching them. The bracket will fit over both the Absolyte and Delco batteries. The handle of the Absolyte may be placed under the bracket. Non-conductive material, such as a watertight door gasket, may be used to improve the fit between the bracket and the battery. Secure the bracket to the strong-back bolts with washer and nut. Use the slotted holes on the bracket to "snug" the legs of the bracket against the box.

Secure the platform tether chain to one of the strong-back bolts using a second washer and nut. At each end of the battery box, firmly fit the end brackets against the box and lag bolt them to the decking.

Secure the battery box cover with fasteners, such as web straps, wire ties, or banding material. Wrap the fasteners around the box, parallel to the top bracket and on both sides of the top bracket.

See Figure 21-1 on the following page.

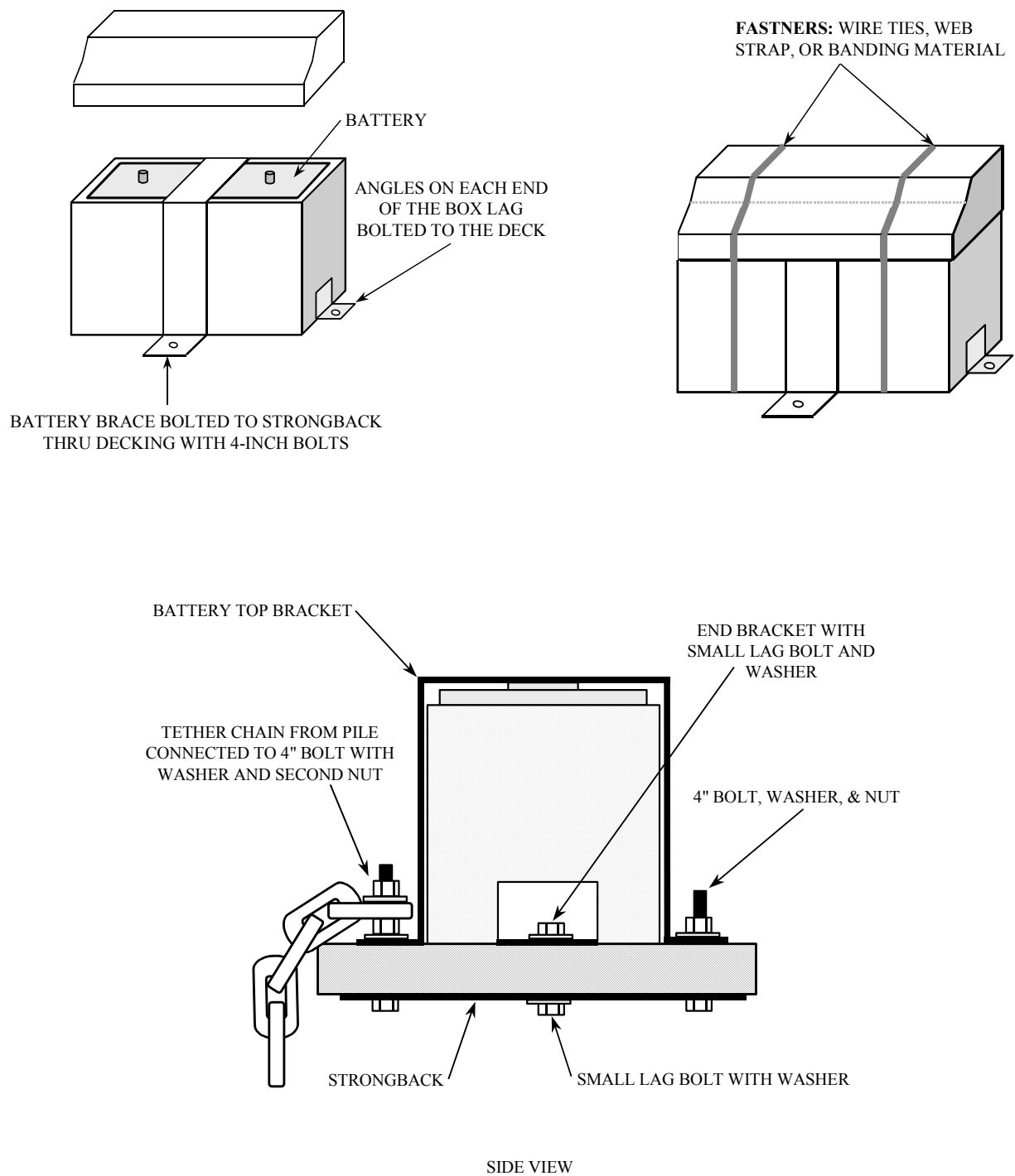


Figure 21-1 - Battery Bracing

Pile Tethering.

The following procedures refer to the tethering of a single pile wood structure. Multiple pile wood structures can also be tethered in this manner; in such a case, only one leg of the structure would need to be tethered.

1. Use 1/4 inch galvanized chain, available commercially.
2. Before driving the pile, attach one end of the tethering chain with a 3-inch lag bolt and flat washer, 10 feet below the estimated mud line. Piles usually break 5 foot below the mud line, so the chain must be attached below this point to be effective.
3. Attach the upper end of the tethering chain to the pile with a 6-inch lag bolt and flat washer. It should be located at a point that will be above the mud line and below the waterline when the pile is driven to its proper depth. A 1/4-inch screw pin shackle may be used in the upper link of the chain to accommodate the 6-inch lag bolt.
4. Leave enough slack between the upper and lower attachment points to keep the tethering chain from becoming taught and absorbing shock during a collision. The purpose of the tether is not to keep the pile from breaking, but to keep the wreckage on its charted position to reduce search time and increase the probability of recovery. During recovery, the 3-inch lag bolt connecting the wreckage to the stub will pull out under a slight strain. The recovered chain is then reusable.

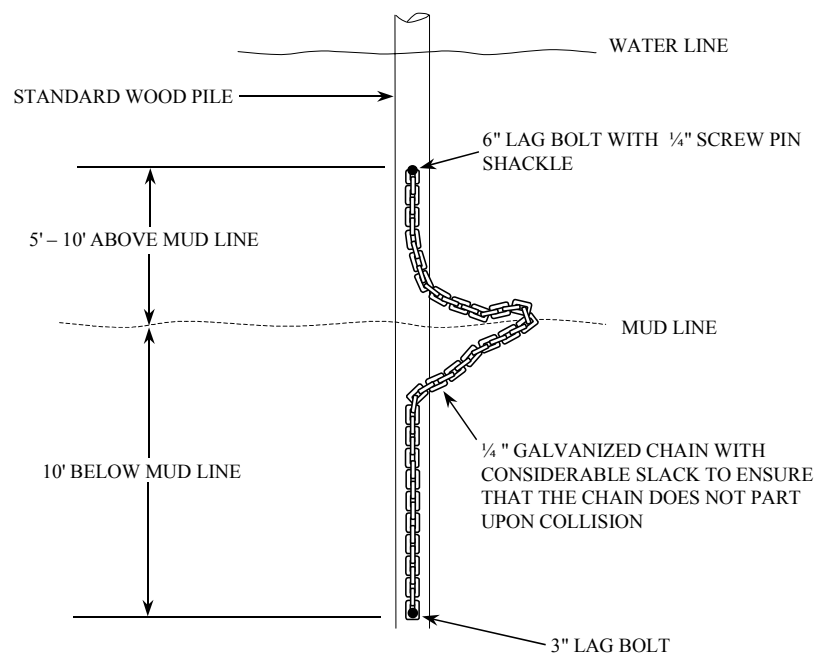


Figure 21-2 - Pile Tethering

Platform Reinforcement.

1. Use lag bolts in conjunction with steel angle brackets to strengthen the connection between the decking and the platform frame. The angles used should be at least 3x3x1/4 inch in size.
2. Use a sufficient number of additional lag bolts or through bolts to reinforce the connection of the platform frame to the piling. When possible, avoid lag bolting through the angle brackets into the pile. This is to keep the wood frame from splitting loose from the angle brackets where the lag bolts attach to the pile, if the platform is ripped from the pile during a collision.

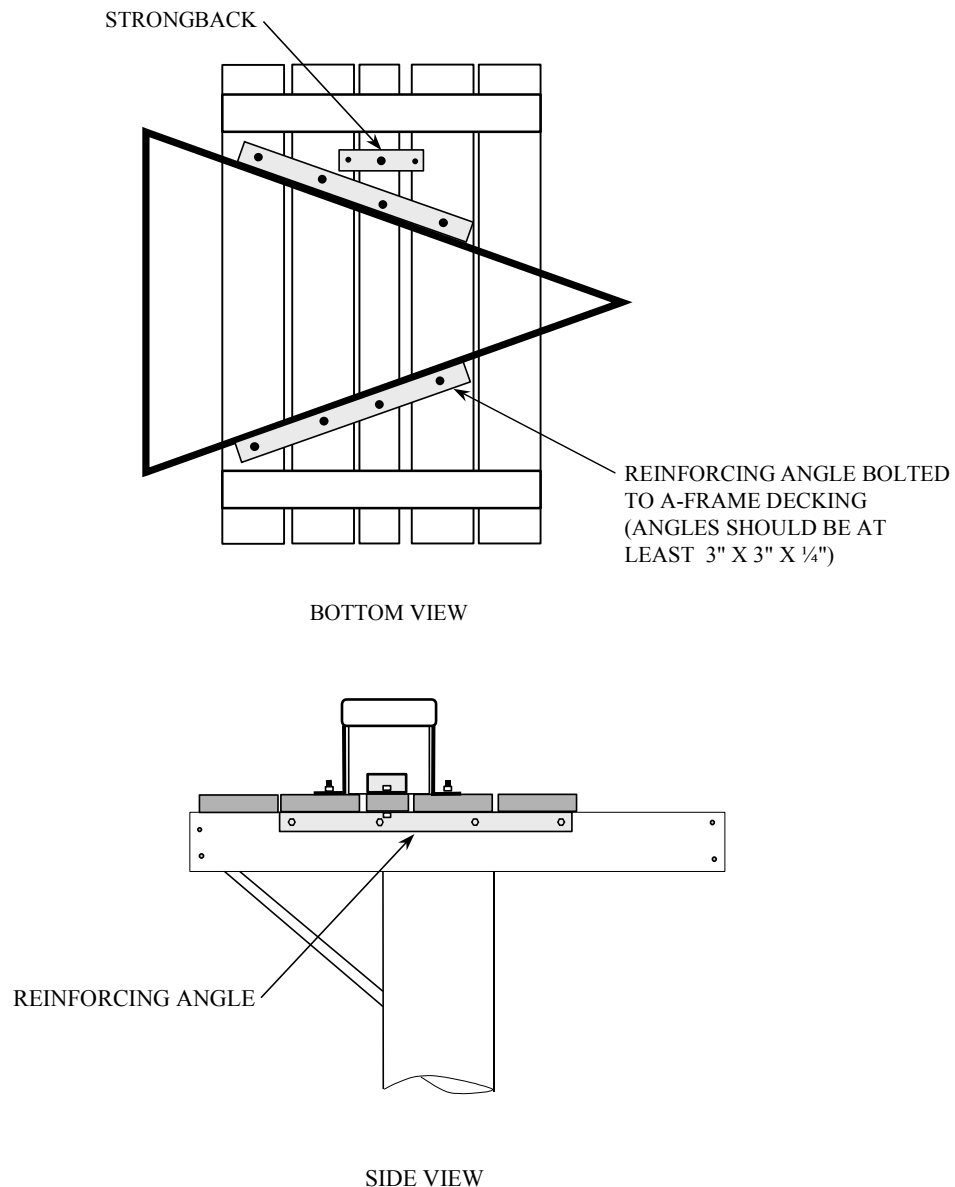


Figure 21-3 - Platform Reinforcement

Platform Tethering.

1. Use 3-inch lag bolts and flat washers to attach two 6-foot lengths of $\frac{1}{4}$ -inch galvanized chain to the pile, 1 foot below the platform. The lengths of chain should be attached opposite each other on either side of the pile. Bolt the end of one of these chain lengths through the reinforcement angle bracket and into the A-frame, using a lag bolt and flat washer. Lead the end of the other chain length to the top of the platform, place the last link over one of the battery bracing bolts, and secure with a nut and flat washer.

2. These tethers are intended to perform a similar role to the one that connects the pile to the stub. They are not meant to keep the platform on the pile, but rather to keep the platform with the pile after it has been torn off.

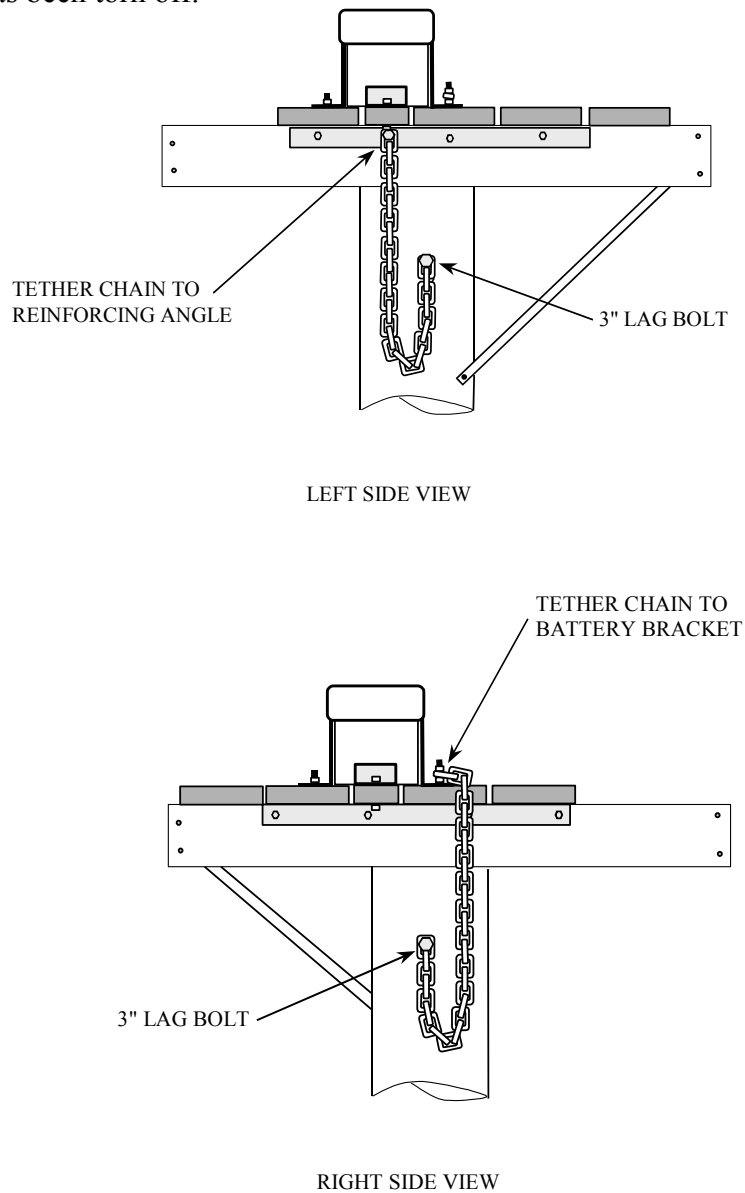


Figure 21-4 - Platform Tethering